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Comparison of Store Airloads from 5.0 and 7.5 Percent F-15 Wind Tunnel Tests

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MUNITIONS DIVISION
AIRCRAFT COMPATIBILITY BRANCH

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This report compares 5.0 and 7.5 percent scale aerodynamic force and moment data from external stores on the F-15 aircraft. The data was obtained at Mach numbers 0.80, 0.95, 1.05, and 1.20. Angles of attack tested were -6, -4, -2, 0, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20 degrees with angles of sideslip -8, 0, +8 degrees. Data taking hysteresis effects are also explored, as well as inboard pylon to centerline pylon effects on the data.

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PREFACE

This study was conducted by the Aircraft Compatibility Branch of the Munitions Division under the F-15 Implementation Plan during the period September 77 to June 78.

This technical report has been reviewed and is approved for publication.

This report has been reviewed by the Information Officer (OI) and is releasable to the National Technical Information Service (NTIS). At NTIS it will be available to the general public, including foreign nations.

FOR THE COMMANDER

John R Taylor

JOHN R. TAYLOR, Colonel, USAF
Chief, Munitions Division

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LIST OF ABBREVIATIONS, ACRONYMS, AND SYMBOLS

ALPHA	Angle of attack (positive nose up) pylon axis system
BETA	Angle of sideslip (positive nose left) pylon axis system
BL	Butt line location
$\bar{c}_p$, l_{REF}	Reference length (inches)
CNPL	In-board pylon normal force coefficient (positive up)
CMPL	In-board pylon pitching moment coefficient (positive nose up)
CYPL	In-board pylon yaw force coefficient (positive right)
CLNP	In-board pylon yawing moment coefficient (positive nose right)
CLLP	In-board pylon roll moment coefficient (positive clockwise looking from rear)
FS	Fuselage station
P1	Free stream static pressure, psfa
PT1	Free stream stagnation pressure, psfa
Q1	Free stream dynamic pressure, psfa
$Rx10^{-6}$	Free stream unit Reynolds Number x 10^{-6}, per foot
Sp, S_{REF}	Reference area, sq ft
WL	Water Line Station

SECTION I

INTRODUCTION

Carriage airloads testing of larger scale aircraft and store models in large wind tunnels is costly. To reduce this cost, future testing must be done in smaller wind tunnels with, of course, smaller scale models. Scale effects, if any, must be determined before any such changeover in testing policy can be seriously considered. To evaluate this possibility, carriage airloads data from a large wind tunnel/large scale models must be compared with data from a smaller wind tunnel/smaller scale models. In 1970, carriage airloads data were obtained with a 7.5-percent model F-15 and several external stores in Arnold Engineering Development Center (AEDC) 16-foot Transonic Wind Tunnel (16T). In 1977, carriage airloads data were obtained with a 5-percent scale model F-15 and several of the same type external stores in the 4-foot Transonic Wind Tunnel (4T) at AEDC. Since these data represent the only scales of the F-15 that have been tested, validation of these data with actual flight conditions is not an objective of this report. Thus, the purpose of this report is to compare the two sets of data to determine feasibility of using 5-percent models in 4T in lieu of 7.5-percent models in 16T.

SECTION II

APPARATUS

2.1 TEST FACILITIES. The 16-foot Transonic Tunnel (16T) is a closed-circuit, continuous flow wind tunnel normally operated at Mach numbers from 0.2 to 1.6 at stagnation pressures ranging from approximately 200 to 3400 psfa, depending upon the Mach number. A more extensive description of the tunnel and its full range of operating characteristics is contained in Reference 1.

The 4-foot Transonic Tunnel (4T) is a closed-loop, continuous flow, variable density tunnel in which the Mach number can be varied from 0.1 to 1.3. Also, nozzle blocks can be installed to give nominal Mach numbers of 1.6 and 2.0. At all Mach numbers, the stagnation pressure can be varied from 300 to 3700 psfa. The test section is 4 feet square and 12.5 feet long with perforated, variable porosity (0.5- to 10-percent open) walls. It is completely enclosed in a plenum chamber from which the air can be evacuated, allowing part of the tunnel airflow to be removed through the perforated walls of the test section. A more complete description of the test facility can be found in Reference 1.

The model support system consists of a sector and sting attachment which has a pitch angle capability of -7.5 to 28 degrees with respect to the tunnel centerline and a roll capability of -180 to 180 degrees about the sting centerline.

2.2 TEST MODELS. The 5.0-percent F-15 model and its external stores are presented in Figures 1 through 9. The external stores used in the 7.5-percent test are shown in Figures 10 through 14. Note the discrepancies between some of the models.

(1) The Multiple Ejector Racks (MER) racks are different types.

(2) The 5.0-percent 600-gallon tank has a smaller fin than the 7.5-percent tank.

(3) The 5.0-percent SUU-41 was substituted for the 7.5-percent CBU-42A. Although similar in shape, when set to the same scale, the lengths differ by nearly 6 percent, the diameters by 13 percent.

(4) The 5.0-percent model's inboard pylon thickness was increased by 0.1 inch over true scaled model dimensions. This was required to allow the necessary side clearances between the balance and the inside of the pylon wall.

2.3 INSTRUMENTATION. Test instrumentation included a six-component main balance and a five-component carriage airloads balance for force and moment measurements. For the 5.0-percent test, the carriage airloads balance was an integral part of the left inboard pylon measuring forces transmitted to the pylon by the MER and/or store(s). For the 7.5-percent test, the carriage airloads balance was an integral part of the F-15 left wing measuring forces transmitted to the wing by the pylon and MER and/or stores. This is a source of potential differences between the data since one test measured forces at the wing/pylon interface while the other measured forces at the pylon/rack-store interface. In addition, because of space constraints, axial force links could not be incorporated into the carriage airloads balance for the 5.0-percent scale test and hence, the axial force loads of the various store configurations could not be determined. Sketches of the carriage airloads balance and pylon assemblies with the MERs installed are presented in Figures 15 and 16.

SECTION III

TEST DESCRIPTION

3.1 TEST PROCEDURE AND CONDITIONS. Both aircraft model and carriage loads force and moment data were obtained using the pitch-pause technique to incrementally vary the F-15 model angle of attack while holding Mach number, dynamic pressure and sideslip angle constant. The Mach numbers ranged from 0.80 to 1.20. The angle-of-attack range was generally from -6 to 20 degrees at sideslip angles of 0, ± 4, and ± 8 degrees. However, for some of the configurations the maximum angle-of-attack was limited to 10 to 12 degrees for $\beta = 4$ and 8 degrees because of load limitations of the carriage loads balance. The combined attitude polars were run automatically using on-line computer facilities which set the model pitch and roll angles to give the prescribed values of angle of attack and sideslip. A summary of the nominal test conditions set during these tests are presented in Table 1. The five configurations tested are shown in Figure 17.

3.2 DATA REDUCTION AND CORRECTIONS. The carriage loads data were reduced in the body axis system. The reference areas, lengths and moment reference points for the carriage loads data are presented in Table 2. At the moment reference point given in this table for the carriage loads data, and shown in Figure 15, the carriage loads pitching moment coefficients determined during the 5.0-percent test must be corrected by an estimated axial force contribution because no axial force measurements could be made for the reasons discussed in Section 2.3. Equation (1) given below was used to correct the tabulated pitching-moment coefficient data from the 5.0-percent test.

$$(\text{CMPL})_{\text{corrected}} = (\text{CMPL})_{\substack{\text{Tab}\\ \text{Data}}} - \frac{(Z_A)\ (F_A)\ \text{estimated}}{\bar{c}_p \ \ s_p \ \ Q1} \qquad (1)$$

where Z_A is the distance between the carriage loads moment reference point and the calibration center shown in Figure 15, and (F_A) estimated is the estimated axial force for the store configuration of interest.

The angles of attack and sideslip were corrected for sting deflections caused by aerodynamic loads. The model was tested both upright and inverted to determine tunnel flow angularity corrections. Flow angularity corrections ranging from 0.45 degrees at Mach number 0.6 to 0 degrees at Mach number 1.05 were applied to the data. Corrections for the components of model weight, normally termed static tares, were also applied to the data.

TABLE 1. SUMMARY OF NOMINAL TEST CONDITIONS

5.0-PERCENT TEST

Mach Number	PT1 (psfa)	P1 (psfa)	Q1 (psf)	R** x 10^{-6} (ft^{-1})
0.80	1200	785	350	2.2
0.90	1200	710	400	2.3
1.10	1200	565	480	2.5
1.30	1200	435	515	2.5

**Based on total temperature of 100 to 110°F.

7.5-PERCENT TEST

Mach Number	Q_∞ (psf)
0.80	300
0.95	300
1.05	300
1.20	300

TABLE 2. REFERENCE DIMENSIONS AND MOMENT REFERENCE POINTS (LEFT INBOARD PYLON)

5.0-PERCENT TEST

CONFIGURATION	S_{REF} (SQ FT)	l_{REF} (INCHES)
1	0.01146	1.4495
2	0.01450	1.6300
3	0.01450	1.6300
4	0.00966	1.3308
5	0.00966	1.3308
MOMENT REFERENCE POINT: FS = 30.107, WL = 6.352, BL = -5.762		

7.5-PERCENT TEST

CONFIGURATION	S_{REF} (SQ FT)	l_{REF} (INCHES)
1	0.02377	2.0876
2	0.03630	2.5650
3	0.03630	2.5650
4	0.02197	2.0071
5	0.02197	2.0071
MOMENT REFERENCE POINT: FS = 45.16, WL = 9.528, BL = -8.644		

3.3 MEASUREMENT UNCERTAINTIES. The balance and instrumentation system uncertainties, based on a 95-percent confidence level, were combined with the uncertainties in the tunnel parameters, using a Taylor series approximation for error propagation, to estimate the uncertainties of the aerodynamic coefficients. Representative uncertainties determined in tunnel parameters and aerodynamic coefficients are given in Table 3. The precision in setting and maintaining a specific Mach number was ± 0.005.

TABLE 3. ACCURACY OF MEASUREMENTS

7.5-PERCENT TEST (ALL MACH NUMBERS)

CONFIGURATION →	1	2	3	4	5
CNPL	±0.0172	±0.0113	±0.0113	±0.0205	±0.0205
CMPL	±0.0877	±0.0467	±0.0467	±0.1138	±0.1138
CYPL	±0.0373	±0.0244	±0.0244	±0.0444	±0.0444
CLNP	±0.0909	±0.0484	±0.0484	±0.1180	±0.1180
CLLP	±0.0508	±0.0271	±0.0271	±0.0659	±0.0659

Q_∞ ± 2 psf
α ± 0.25 deg
β ± 0.10 deg
ϕ ± 0.30 deg

5.0-PERCENT TEST

MACH	CONFIGURATION →	1	2	3	4	5
0.80	CNPL	±0.0302	±0.0304	±0.0304	±0.0457	±0.0457
	CMPL	±0.0151	±0.0135	±0.0135	±0.0248	±0.0248
	CYPL	±0.0907	±0.0913	±0.0913	±0.1370	±0.1370
	CLNP	±0.1055	±0.0944	±0.0944	±0.1736	±0.1736
	CLLP	±0.1356	±0.1214	±0.1214	±0.2222	±0.2233
	Q_∞			±2.35		
0.95	CNPL	±0.0247	±0.0249	±0.0249	±0.0374	±0.0374
	CMPL	±0.0151	±0.0135	±0.0135	±0.0248	±0.0248
	CYPL	±0.0797	±0.0802	±0.0802	±0.1204	±0.1204
	CLNP	±0.0904	±0.0810	±0.0810	±0.1488	±0.1488
	CLLP	±0.1206	±0.1079	±0.1079	±0.1985	±0.1985
	Q_∞			±2.35		
1.05	CNPL	±0.0192	±0.0194	±0.0194	±0.0291	±0.0291
	CMPL	±0.0151	±0.0135	±0.0135	±0.0248	±0.0248
	CYPL	±0.0659	±0.0664	±0.0664	±0.0996	±0.0996
	CLNP	±0.0753	±0.0675	±0.0675	±0.1240	±0.1240
	CLLP	±0.0904	±0.0810	±0.0810	±0.1488	±0.1488
	Q_∞			±2.45		
1.20	CNPL	±0.0192	±0.0194	±0.0194	±0.0291	±0.0291
	CMPL	±0.0151	±0.0135	±0.0135	±0.0248	±0.0248
	CYPL	±0.0604	±0.0609	±0.0609	±0.0913	±0.0913
	CLNP	±0.0753	±0.0675	±0.0675	±0.1240	±0.1240
	CLLP	±0.0904	±0.0810	±0.0810	±0.1488	±0.1488
	Q_∞			±2.48		

$\alpha \pm 0.1^{\circ}$ $\phi = \pm 0.4^{\circ}$

SECTION IV

TEST RESULTS

4.0 The primary purpose of this report is to compare five configurations from the two wind tunnel tests and determine if any scale effects exist. In addition, hysteresis data is presented from configuration 1 to show possible differences in the method of data collection. Configurations 2 and 3 from the 5.0-percent test are compared to determine the effect of a centerline MER load on a 600-gallon tank mounted on the left inboard pylon. All these comparisons consider all five coefficients at all available Mach numbers. Where empty graphs exist, data from the 7.5-percent test was not available or in the case of the hysteresis data, hysteresis checks were not run. A number of unknowns exist that affected the data presented here. First of all, the tests were conducted in two different wind tunnels. The 7.5-percent test was conducted in 16T while the 5.0-percent test was done in 4T. Secondly, the metric balances in the two tests were in different locations. The balance in the 7.5-percent test was in the wing, measuring the store suspension equipment and pylon forces. The 5.0-percent test balance was located in the pylon, measuring only the store and suspension equipment forces. Since normal force and pitching moment of the pylon alone would be small, the fact that the 7.5-percent test measures forces acting on the pylon itself would not appreciably increase the total normal force and pitching moment. However, side force and yawing moment could be markedly affected. Thirdly, the suspension racks from the two tests are different types. Generally, this would only affect the normal force and pitching moment data since the stores mounted on the racks tend to block any side airflow on the racks themselves, thus reducing side force and yawing moment effects on the racks, Lastly, some of the stores are not scaled properly or have different size fin surfaces.

4.1 CONFIGURATION 1. All five coefficients presented in Figures 18 through 22 show good agreement considering that the models tested were not identical. As mentioned previously, the models differed by 6 percent in length and 13 percent in diameter when compared at the same scale. In addition, the physical difference in racks may account for some differences in normal force data. These discrepancies may account for some of the data differences between tests, but considering that the location of the balances in both tests were different (as noted in Section 2.3), quantifying these effects for configuration 1 would be very difficult at best.

4.2 CONFIGURATION 2. Figures 23 through 27 present data of the 600-gallon tank on the inboard pylon. Very good agreement exists for all five coefficients at Beta=0. Two factors contribute to any differences in this data. First, the balance locations differ. In addition, the vertical tail fin on the 7.5-percent tank is quite a bit longer than the 5.0-percent model's fin. The sidewash (outwash) under the wing acts on both the pylon and tail areas causing any load differences. Note that this is especially true for the side force CYPL in Figure 25. The 7.5-percent data has con-

sistently larger negative values than the 5.0-percent test data. Considering that negative CYPL is outboard on the left pylon, the 7.5-percent tail fin is larger, and that forces on the pylon itself are included in the 7.5-percent data, the trend at Beta=0 can be expected.

Very good agreement also exists for the Beta=$\pm 8^{0}$ data. Here again, due to the above factors, the CYPL data shows some expected differences. At $+8^{o}$ Beta the angle of sideslip, β, and the sidewash under the wing combine to make the 7.5-percent data even more negative. Yet at -8^{o} Beta the sideslip angle tends to cancel out any sidewash effects and the data is in even better agreement than at Beta=0.

4.3 CONFIGURATION 3. Configuration 3 results (Figures 28 through 32) also show data from the 600-gallon tank but with a MER load of MK-82 slicks on the centerline pylon. The results show trends identical to those in configuration 2.

4.4 CONFIGURATION 2 VERSUS CONFIGURATION 3. Figures 33 through 37 illustrate any differences between configurations 2 and 3 for the 5.0-percent test. This comparison is made to detect any pylon to pylon effects present between the centerline and inboard pylons. Excellent data agreement in most cases indicates that, in general, the centerline loadings do not appreciably affect the inboard pylon loadings. Since the MER loading on the centerline and the tank on the inboard pylon are quite large physically, the data indicate that smaller stores should have even less effect on each other. Thus, centerline pylon to inboard pylon effects can be ignored.

4.5 CONFIGURATION 4. Data from the two tests compare favorably, Figures 38 through 42. Differences in the pitch plane data can be attributed to the differences between the two racks tested. Differences in the yaw plane data can be attributed to the metric balance location difference. However, since there is no way to quantify these two factors, they may or may not account for all the differences. Consequently, a qualitative judgment is made that the data from the two tests compare favorably.

4.6 CONFIGURATION 5. Configuration 5 is similar to configuration 4 both physically and in the data trends. The reasons for data differences are the same as in configuration 4. Figures 43 through 47 present the data.

4.7 HYSTERESIS DATA. Hysteresis runs were done to evaluate the method of taking data. Data was taken sweeping from negative to positive alphas and then positive to negative alphas. For all conditions tested, the data, Figures 48 through 52, shows no evidence of hysteresis effects. Whether the data was taken with alpha sweeps from negative to positive alpha or from positive to negative alpha, no difference in data values occurred. As a result, data can be taken in the most expedient manner, since no preferred sweep direction exists.

SECTION V

DISCUSSION

5.0 With the number of unknowns present, quantifying the effect of each on data is an impossible task. It is assumed, however, that all the data differences can be attributed to these uncalculable factors. At first this may seem to be a rash judgment; however, no concrete, consistent evidence was found to uphold a scale effects conclusion. On the other hand, the data differences can logically be attributed to these other factors. In any case, the data differences shown here are small in most instances. Consequently, the small scale data would be an acceptable approximation to the larger scale data regardless of the source of error.

SECTION VI

CONCLUSIONS

6.0 The overall conclusion of this analysis is that 5.0-percent scale airloads testing is a viable alternative to 7.5-percent scale testing. This conclusion allows future airloads testing to be done in 4T, resulting in a significant cost savings over 16T testing. Two other conclusions resulting from this test are that (1) no data taking hysteresis effects exist for alpha sweeps and (2) inboard pylon data is not affected by loadings on the centerline pylon.

SECTION VII

RECOMMENDATIONS

7.0 This analysis was accomplished to determine scale effects between 5.0-percent scale and 7.5-percent scale testing. A comparison of 5.0-percent scale and even larger scale than 7.5-percent would be necessary to determine the real-world accuracy of 5.0-percent scale testing. It would also be desirable to eliminate as many of the unknowns inbedded in this analysis as possible for just such a comparison. Pylon to pylon effects should be more intensely explored for all pylon locations on the F-15.

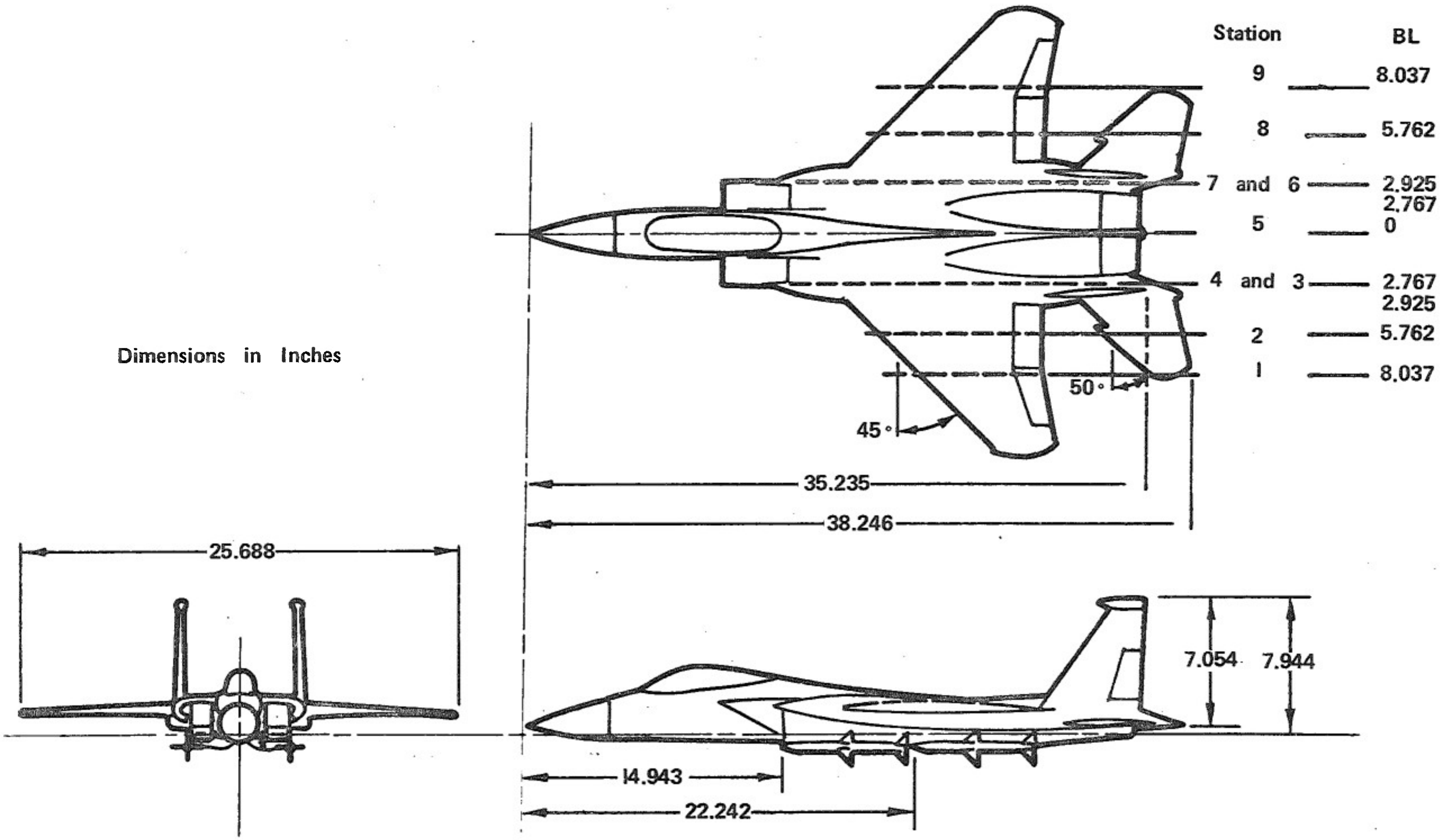
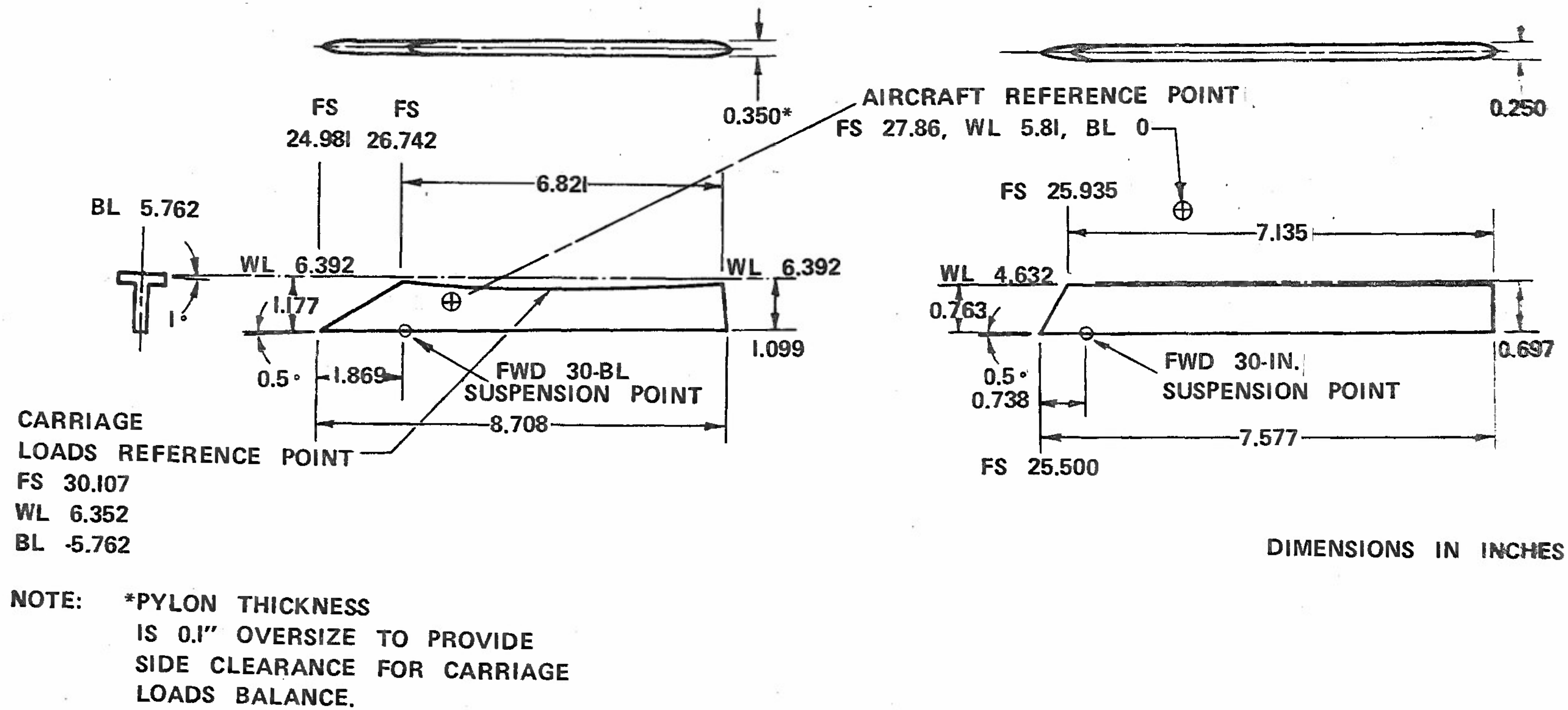


Figure 1. 0.05-Scale F-15 Model



a. Inboard wing pylon

b. Centerline pylon

Figure 2. 0.05-Scale F-15 External Store Suspension Equipment

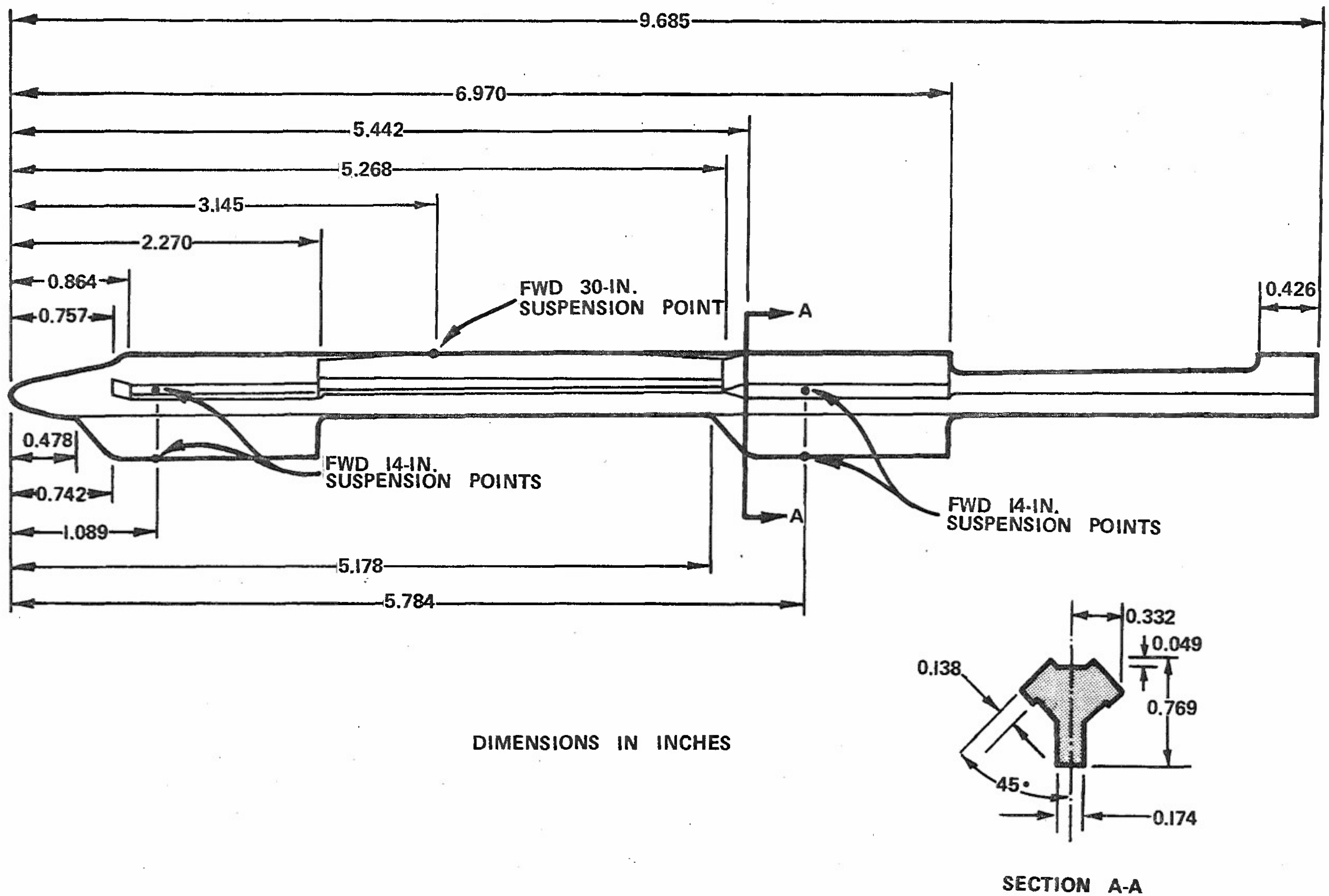
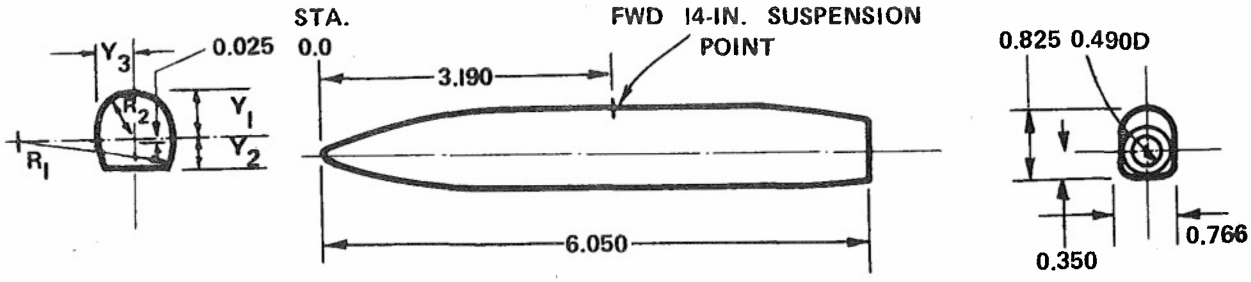


Figure 3. 0.05-Scale F-15 Multiple Ejector Rack, MER-200 Model



DIMENSIONS IN INCHES

STATION	Y_1	Y_2	Y_3	R_1	R_2
0	0	0	0	0	0
0.100	0.064	0.064	0.058	0.117	0.065
0.200	0.096	0.099	0.085	0.203	0.098
0.300	0.127	0.132	0.110	0.287	0.131
0.400	0.159	0.162	0.134	0.370	0.164
0.500	0.189	0.191	0.156	0.452	0.195
0.600	0.219	0.216	0.178	0.530	0.227
0.700	0.247	0.240	0.199	0.610	0.256
0.800	0.273	0.261	0.218	0.688	0.282
0.900	0.297	0.282	0.236	0.765	0.307
1.000	0.319	0.301	0.254	0.842	0.331
1.100	0.340	0.319	0.272	0.920	0.353
1.200	0.360	0.336	0.289	0.995	0.374
1.300	0.379	0.349	0.306	1.070	0.395
1.400	0.397	0.350	0.321	1.145	0.414
1.500	0.413		0.335	1.215	0.432
1.600	0.427		0.347	1.290	0.446
1.700	0.440		0.357	1.357	0.460
1.800	0.451		0.365	1.425	0.473
1.900	0.461		0.372	1.490	0.483
2.000	0.469		0.379	1.555	0.493
2.070	0.475		0.383	1.600	0.500
4.980	0.475		0.383	1.600	0.500
5.050	0.469		0.379	1.555	0.493
5.150	0.461		0.372	1.490	0.483
5.250	0.451		0.365	1.425	0.473
5.350	0.440		0.357	1.357	0.460
5.450	0.427		0.347	1.290	0.446
5.550	0.413		0.335	1.215	0.432
5.650	0.397	0.350	0.321	1.145	0.414
5.750	0.379	0.349	0.306	1.070	0.395
5.850	0.360	0.336	0.289	0.993	0.374
5.927	0.335	0.323	0.276	0.937	0.358

Figure 4. 0.05-Scale SUU-41, Unfinned

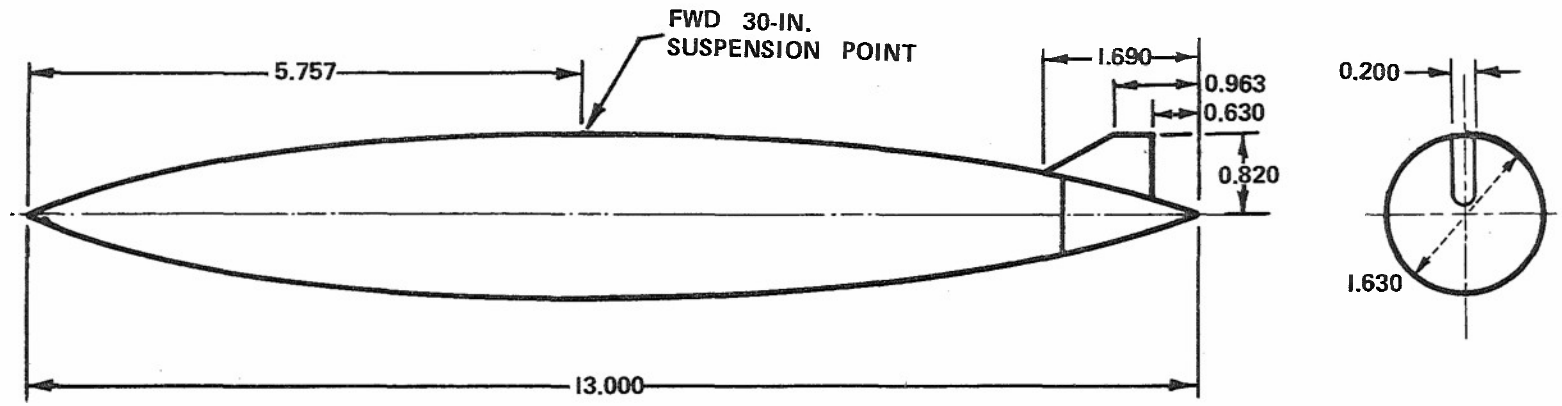


Figure 5. 0.05-Scale 600-Gallon Fuel Tank

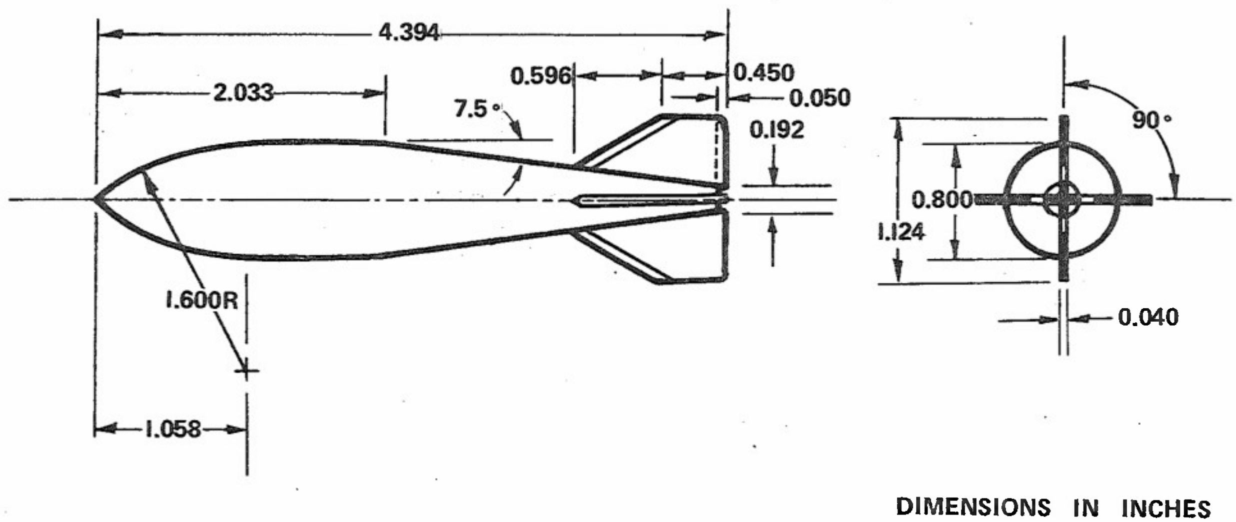


Figure 6. 0.05-Scale M-117 Standard

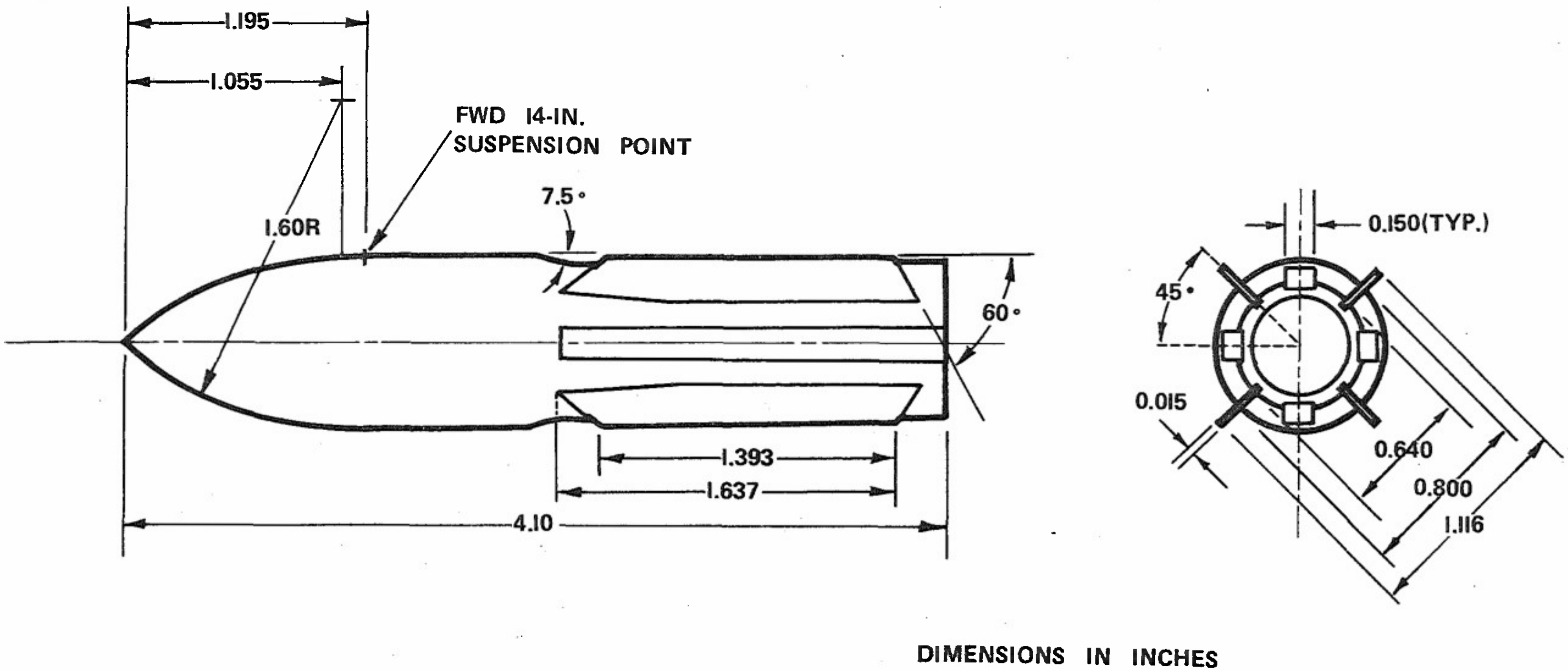
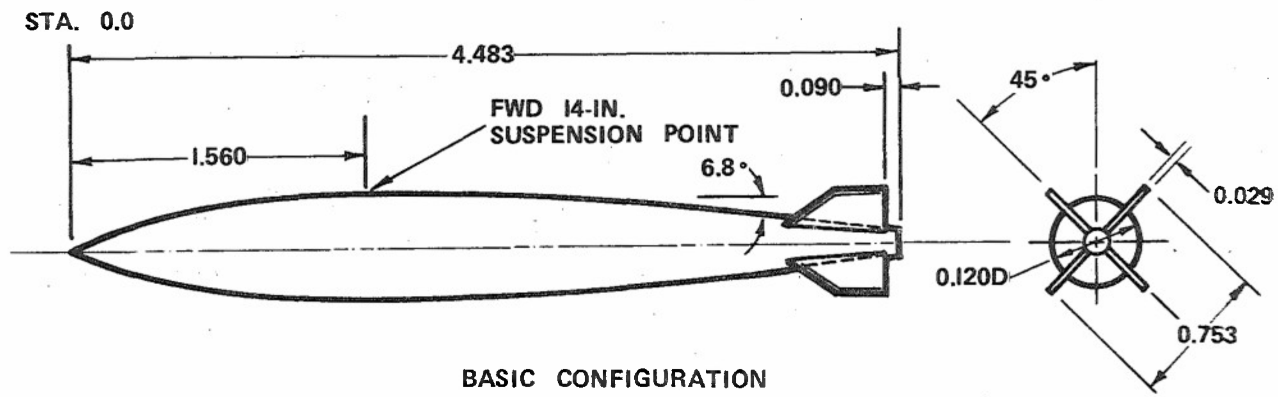
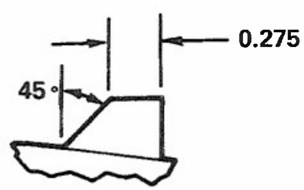


Figure 7. 0.05-Scale M-117 Retarded

STA.	DIAM.
0.000	0.150
0.210	0.150
0.212	0.231
0.312	0.282
0.412	0.322
0.512	0.361
0.612	0.391
0.712	0.421
0.812	0.445
0.912	0.465
1.012	0.483
1.112	0.497
1.212	0.510
1.312	0.520
1.412	0.525
1.512	0.530
1.612	0.532
1.712	0.533
1.812	0.535
1.912	0.537
2.312	0.537
2.412	0.535
2.512	0.525
2.612	0.520
2.712	0.510
2.812	0.497
2.912	0.483
3.012	0.465
3.173	0.438



BASIC CONFIGURATION



FIN DETAILS

DIMENSIONS IN INCHES

Figure 8. 0.05-Scale MK-82 Slick

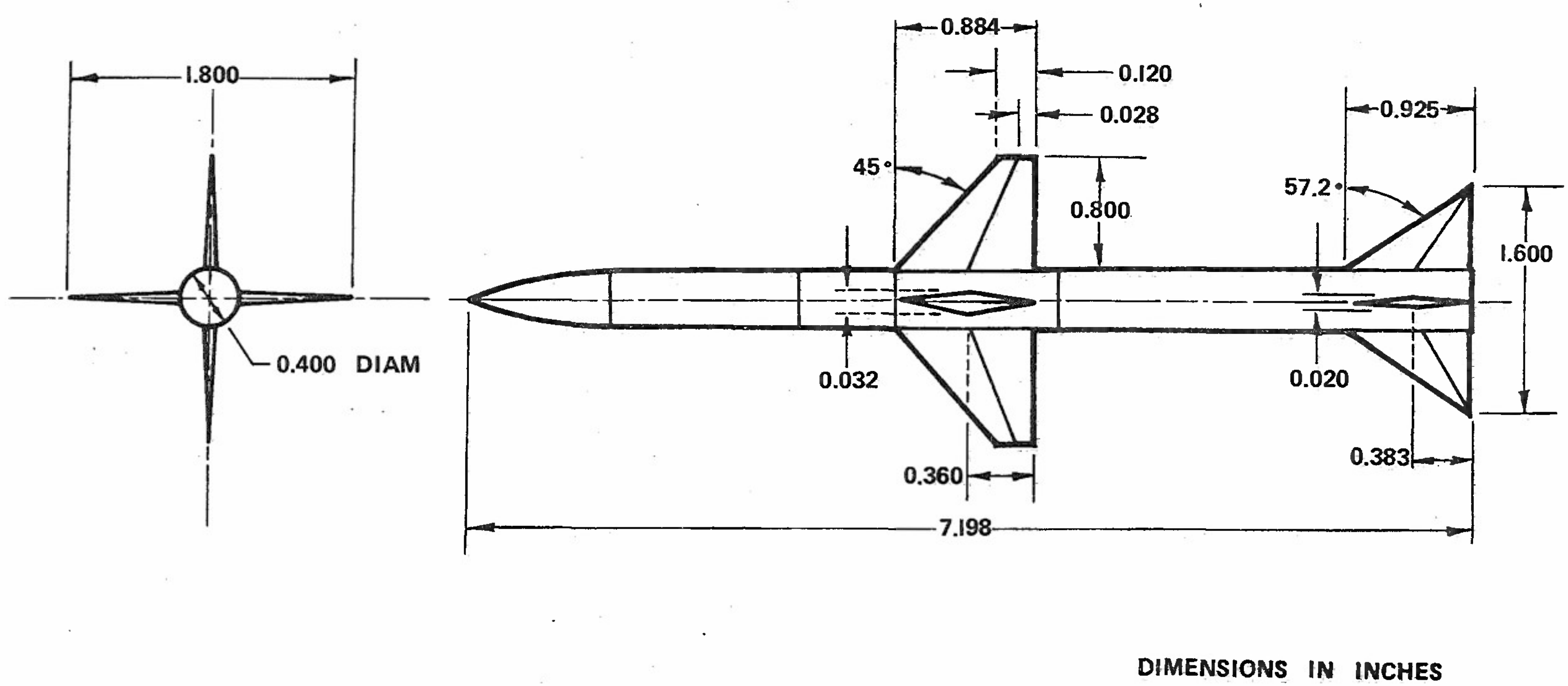


Figure 9. 0.05-Scale AIM-7F

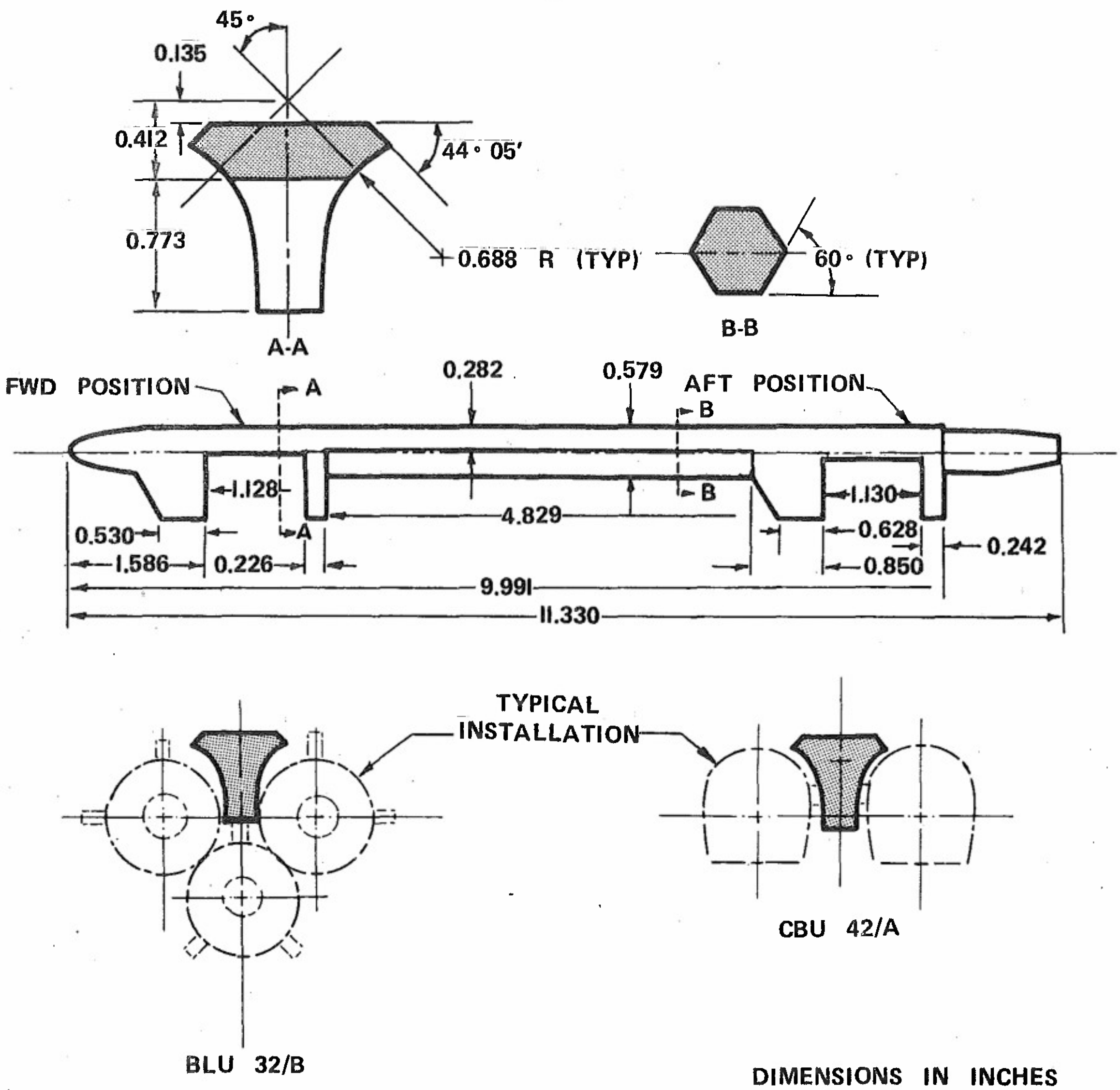
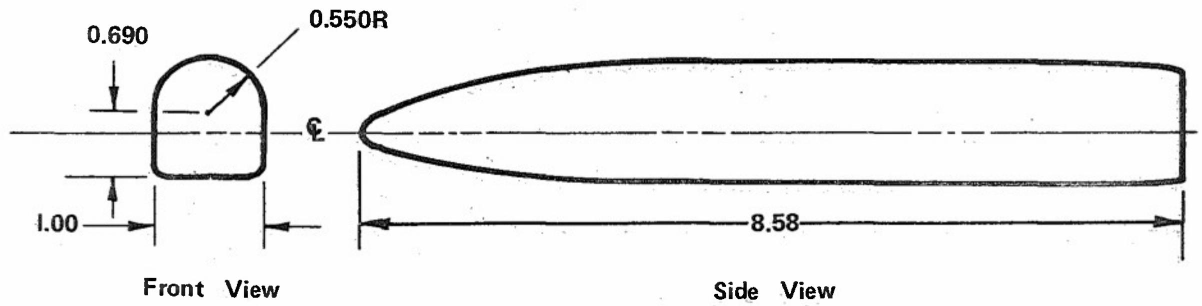


Figure 10. 0.075-Scale F-15 Multiple Ejector Rack



NOTE: All dimensions are in inches model scale

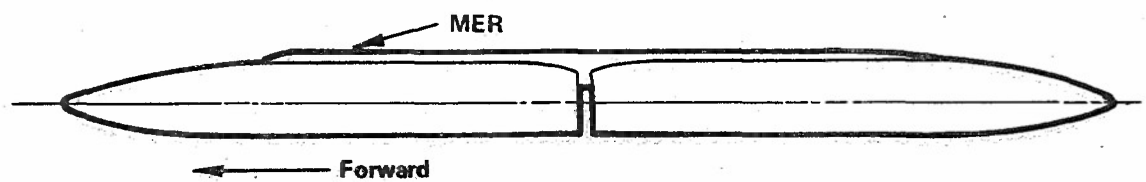
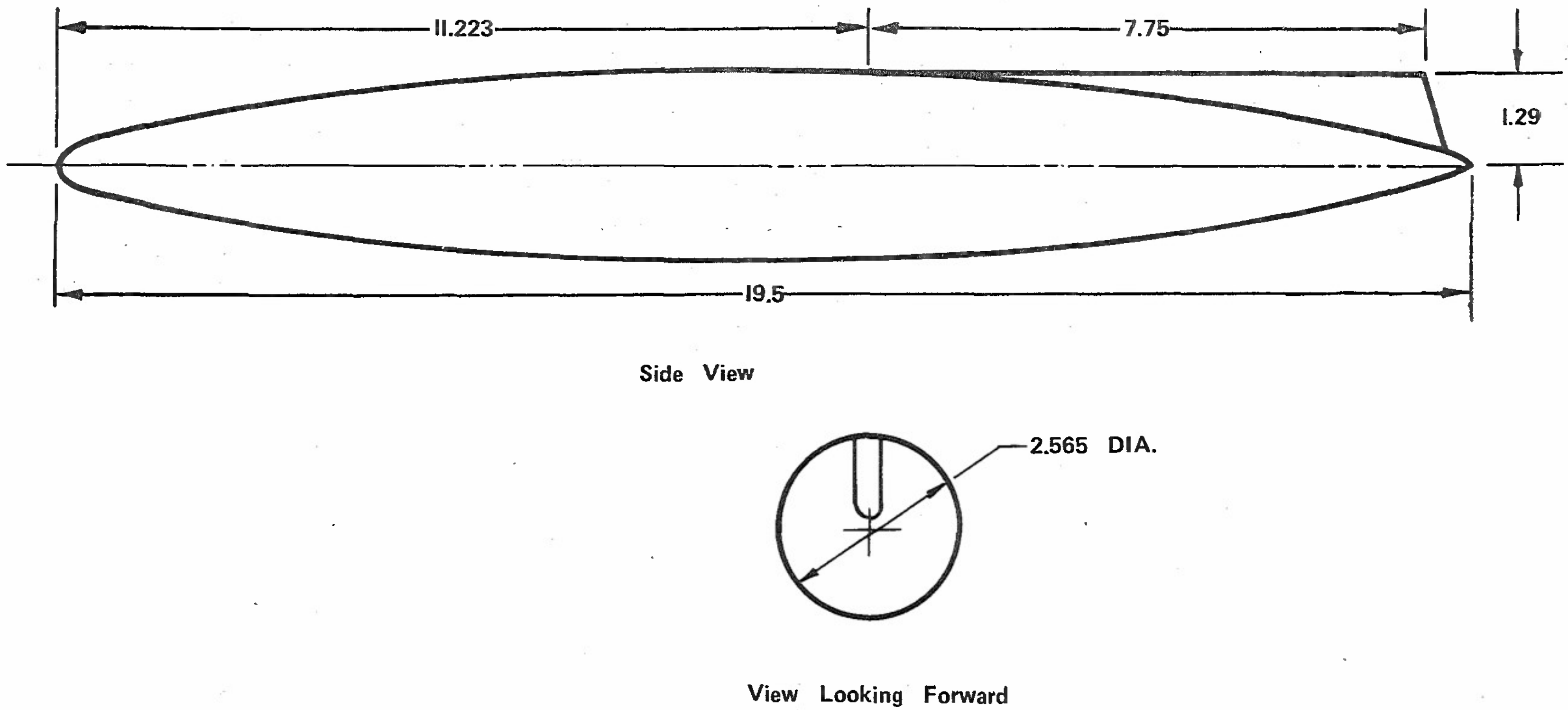
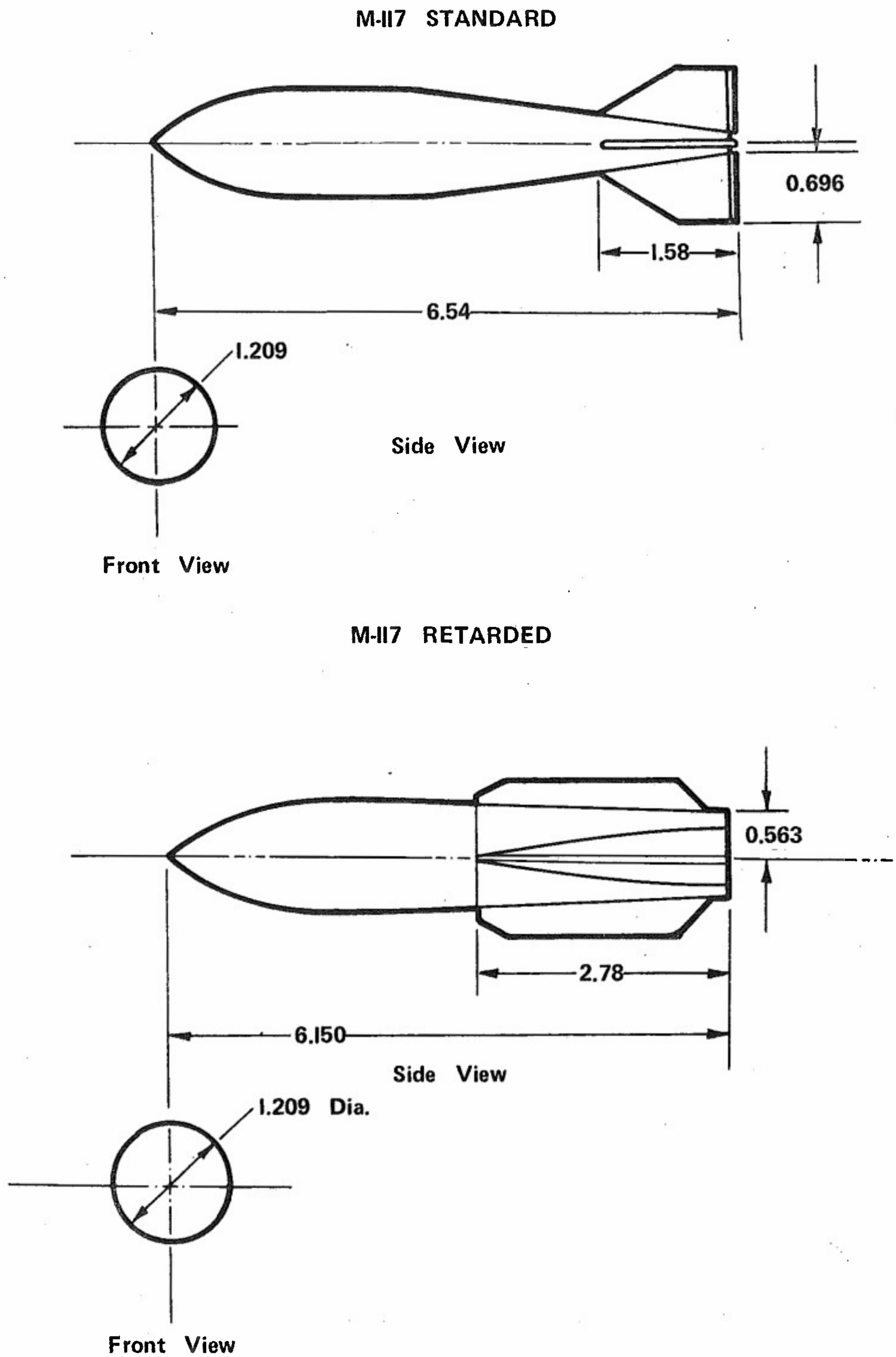


Figure 11. 0.075-Scale CBU-42A



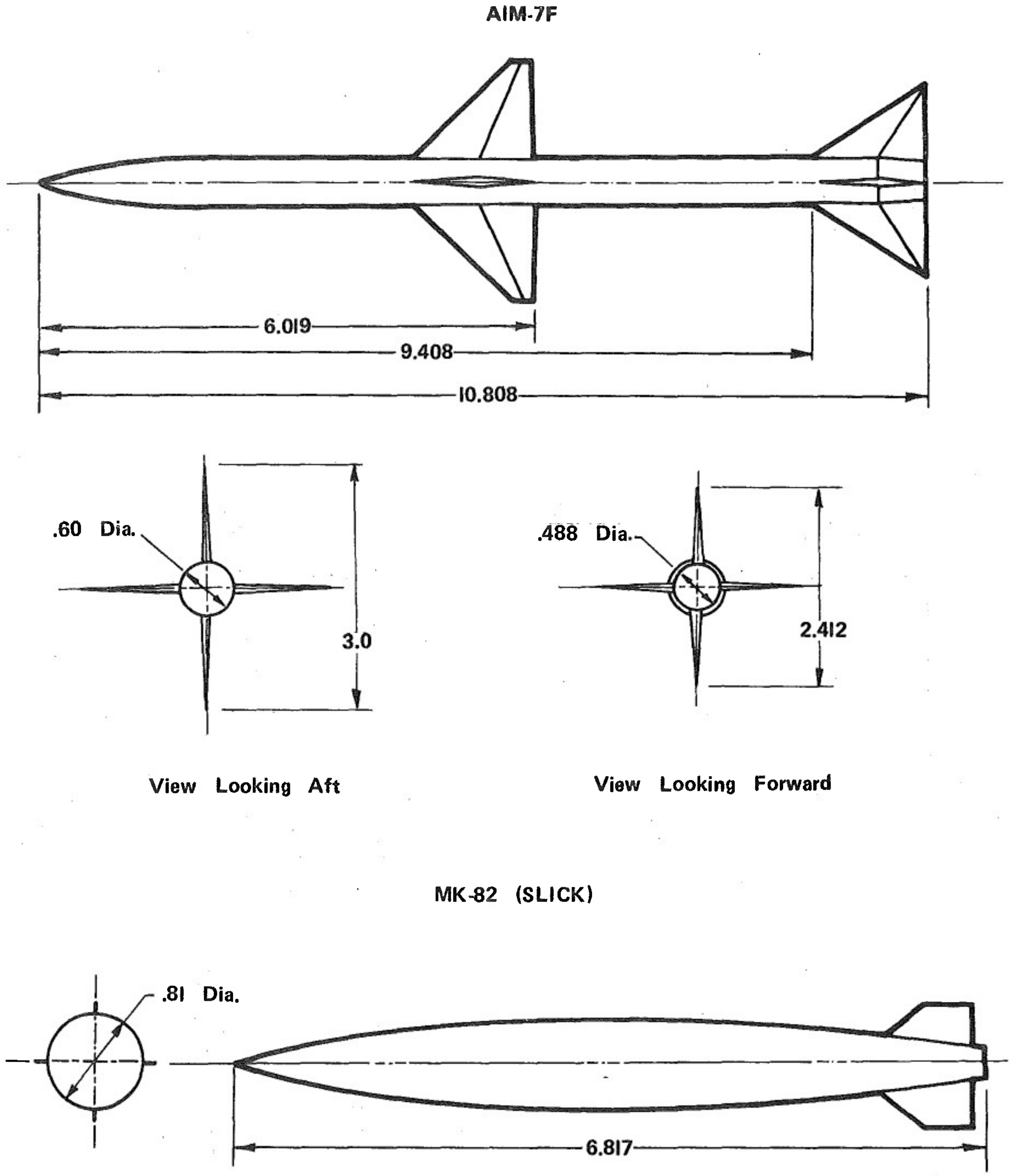
NOTE: All dimensions are in inches model scale

Figure 12. 0.075-Scale 600-Gallon Tank



NOTE: All dimensions are in inches model scale

Figure 13. 0.075-Scale M-117 Standard and Retarded



NOTE: All dimensions are in inches model scale

Figure 14. 0.075-Scale AIM-7F and MK-82 Slick

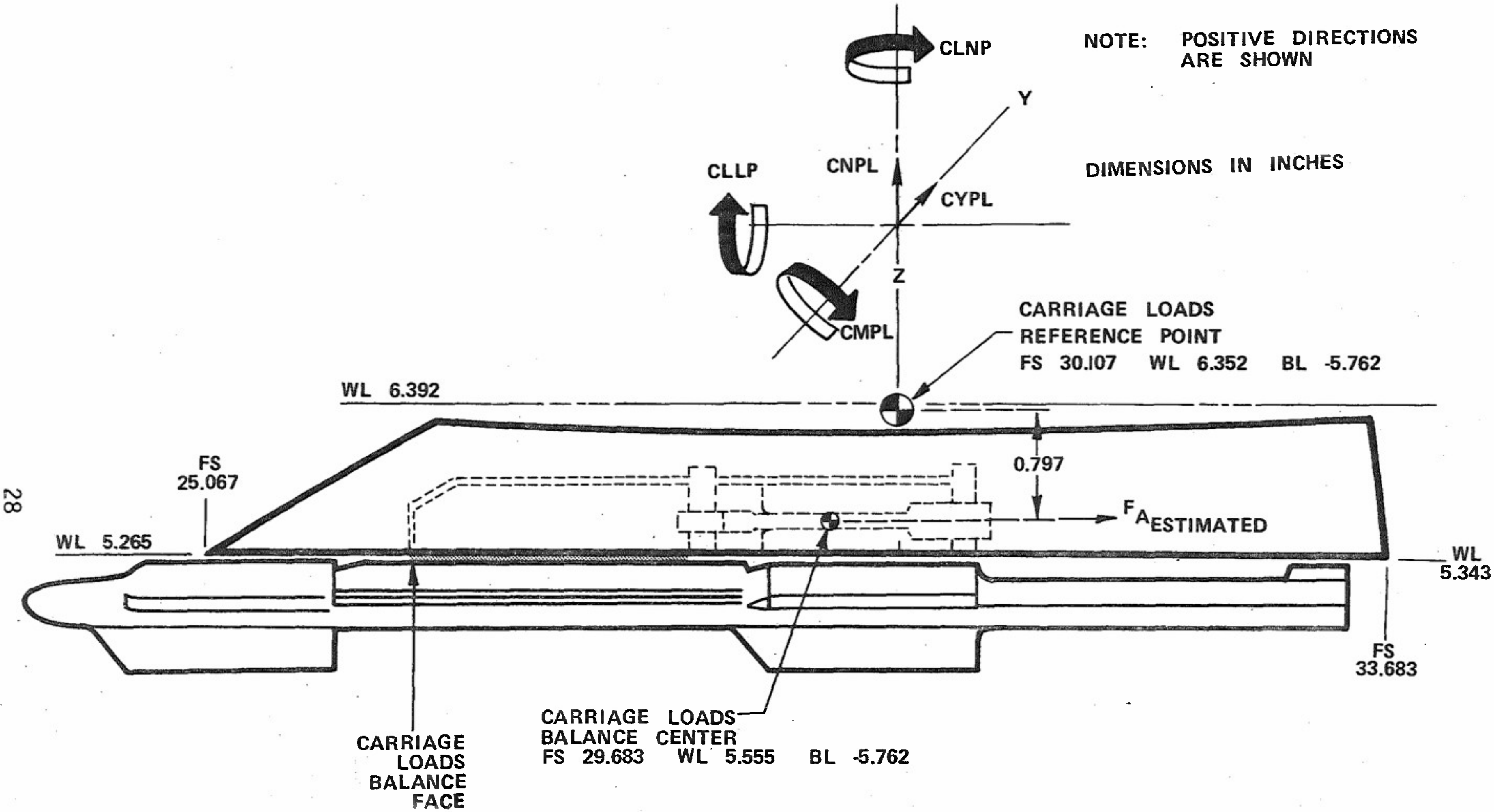
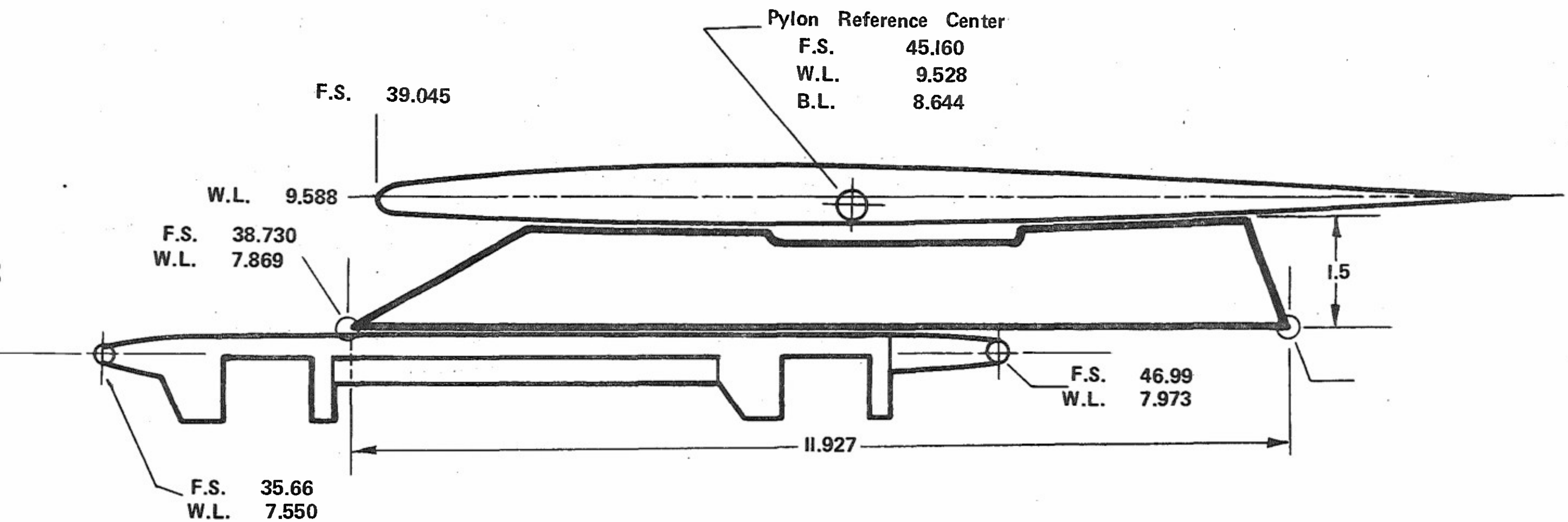
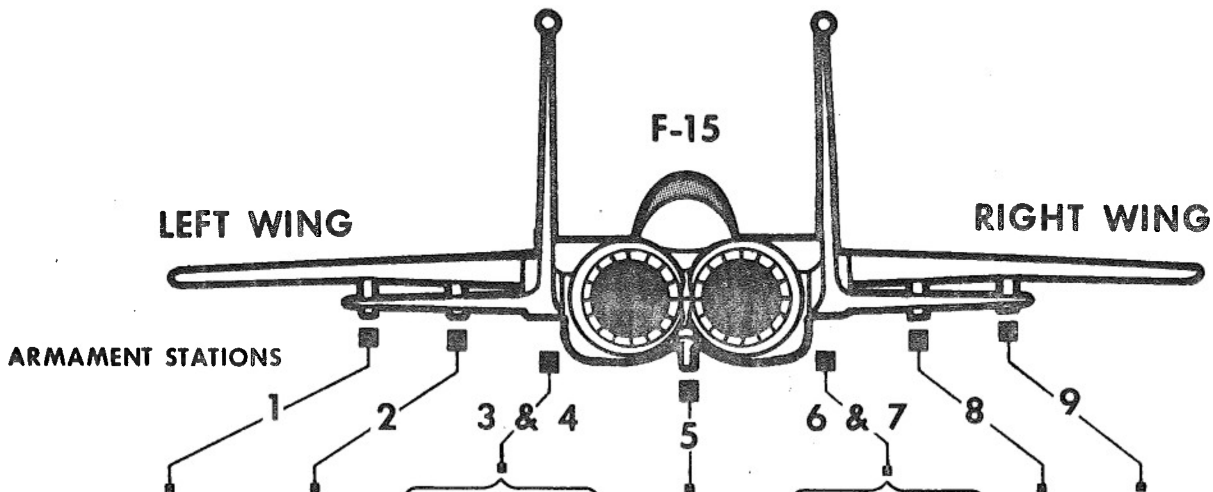


Figure 15. 0.05-Scale Carriage Loads Balance and Pylon Assembly



NOTE: All dimensions are in model scale

Figure 16. 0.075-Scale Carriage Loads Pylon Assembly



Config No		Instrumented Pylon	FWD	AFT		FWD	AFT		
1	Clean	SUU-41 (U) FWD AFT	Clean	AIM-7F	M117S FWD AFT M117R	AIM-7F	AIM-7F	Clean	Clean
2	Clean	600gal Tank	AIM-7F	AIM-7F	Clean	AIM-7F	AIM-7F	Clean	Clean
3	Clean	600gal Tank	AIM-7F	AIM-7F	MK82S FWD AFT	AIM-7F	AIM-7F	Clean	Clean
4	Clean	M117R FWD AFT M117S	Clean	AIM-7F	MK82S FWD AFT	Clean	Clean	Clean	Clean
5	Clean	M117R FWD AFT M117S	Clean	AIM-7F	SUU-41 (U) FWD AFT	Clean	AIM-7F	Clean	Clean

Figure 17. Configuration Key

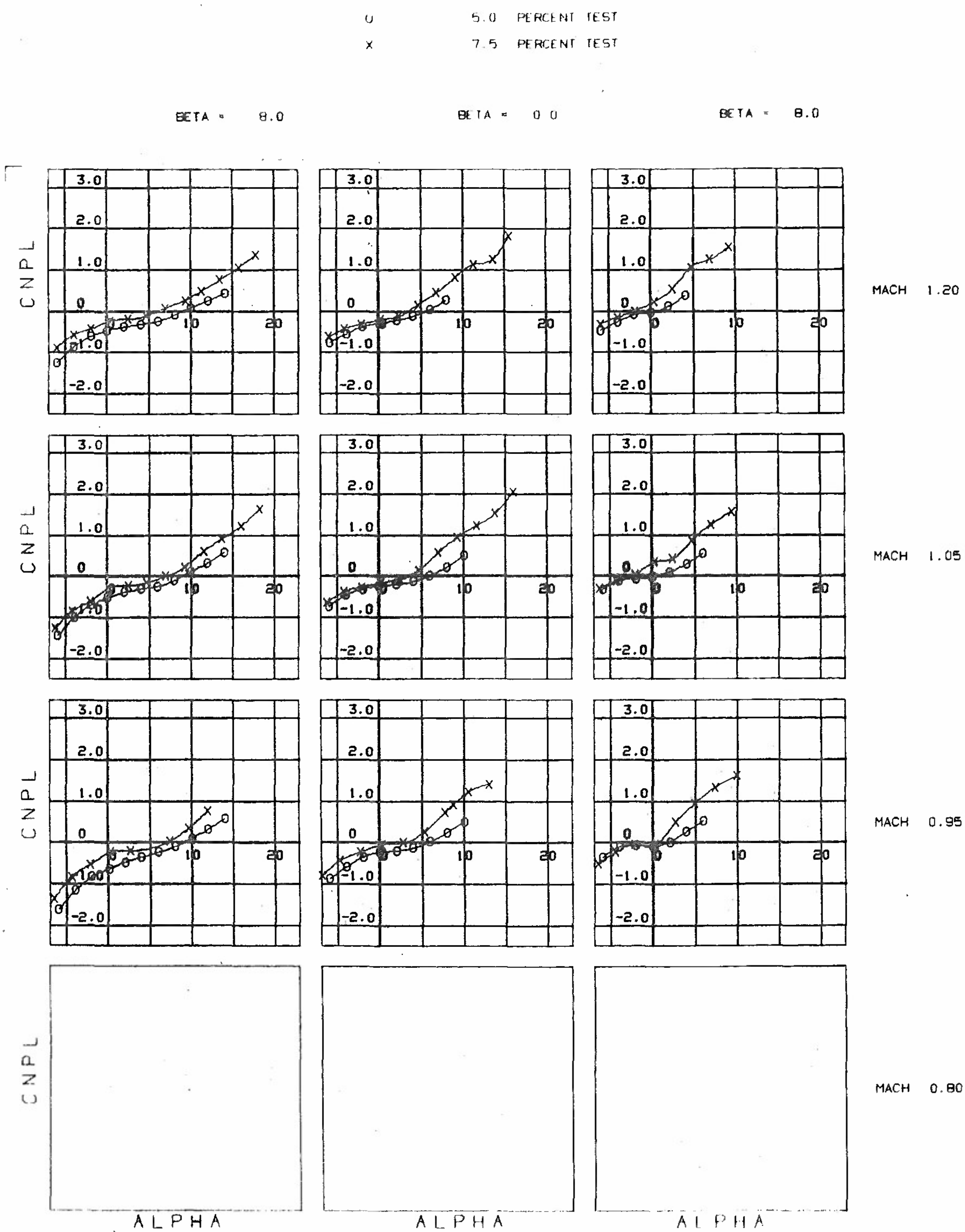


Figure 18. Configuration 1 - CNPL vs ALPHA

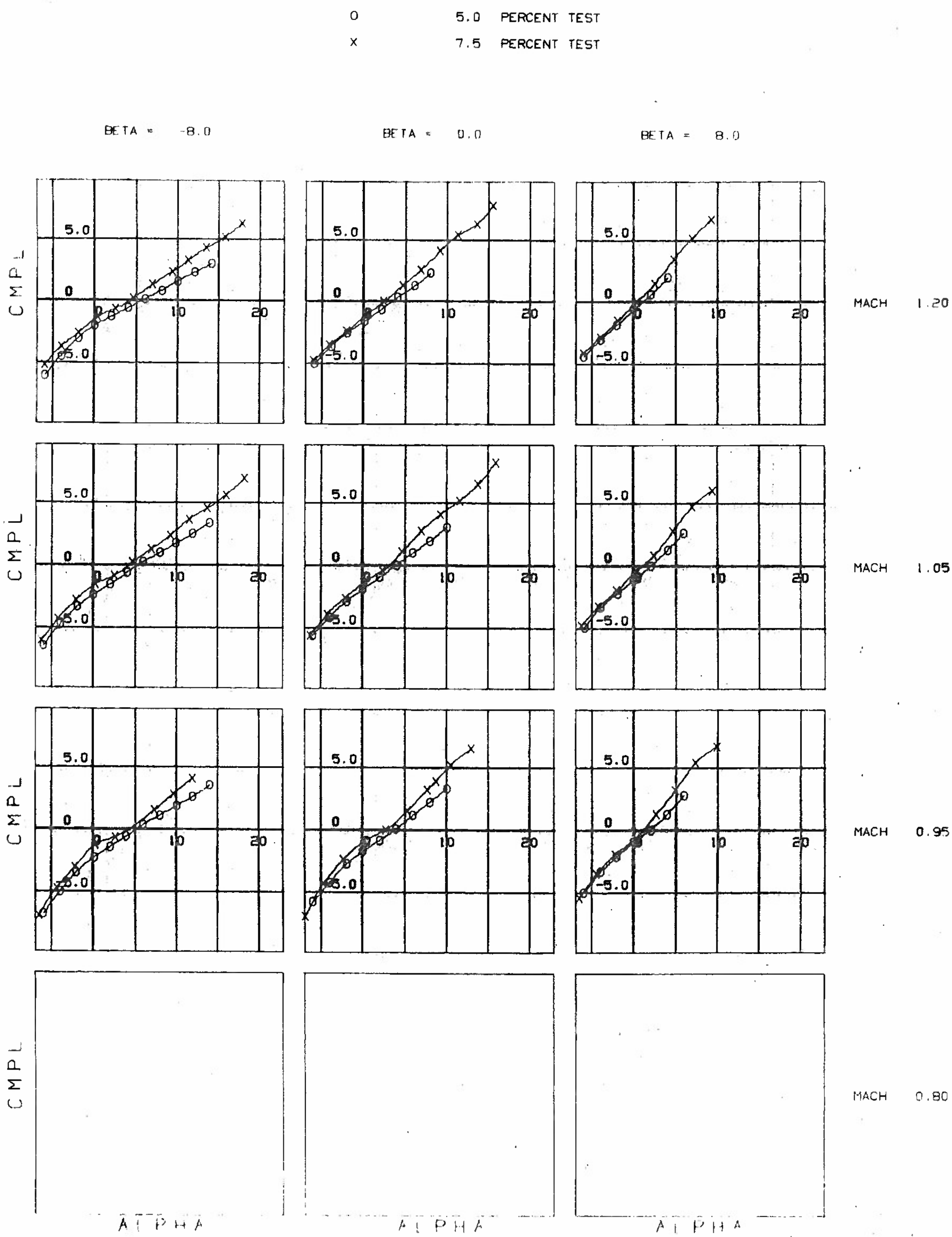


Figure 19. Configuration 1 - CMPL vs ALPHA

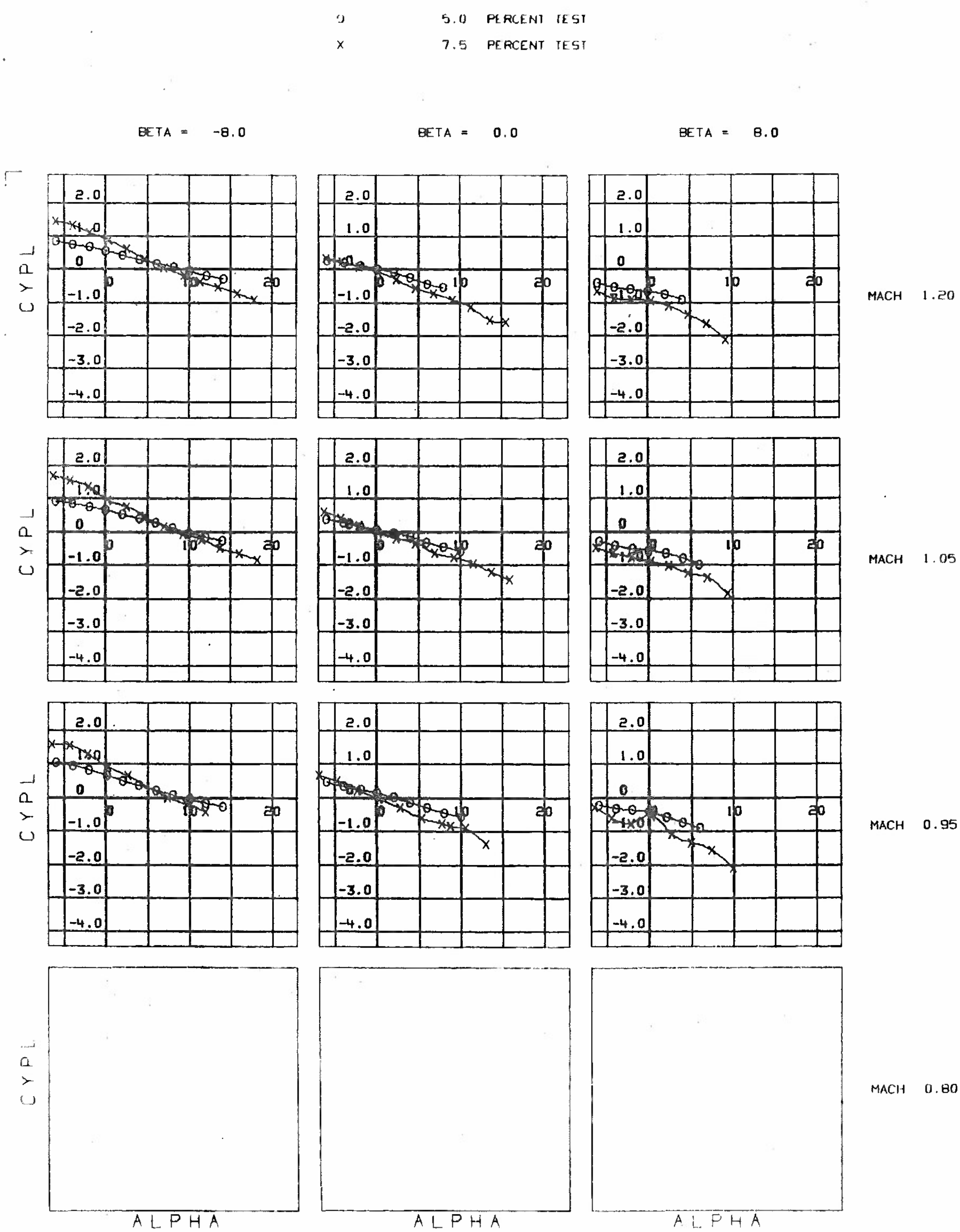


Figure 20. Configuration 1 - CYPL vs ALPHA

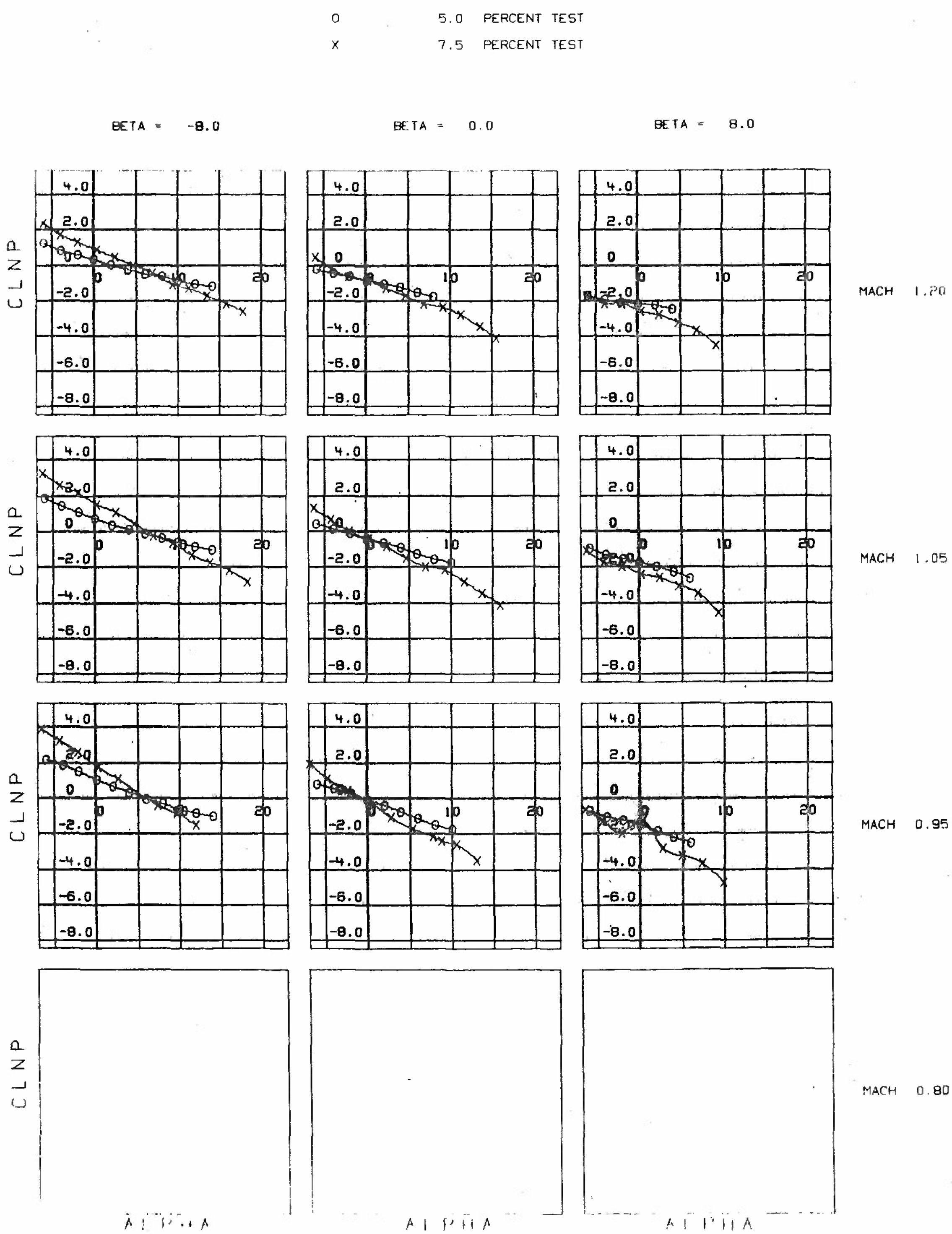


Figure 21. Configuration 1 - CLNP vs ALPHA

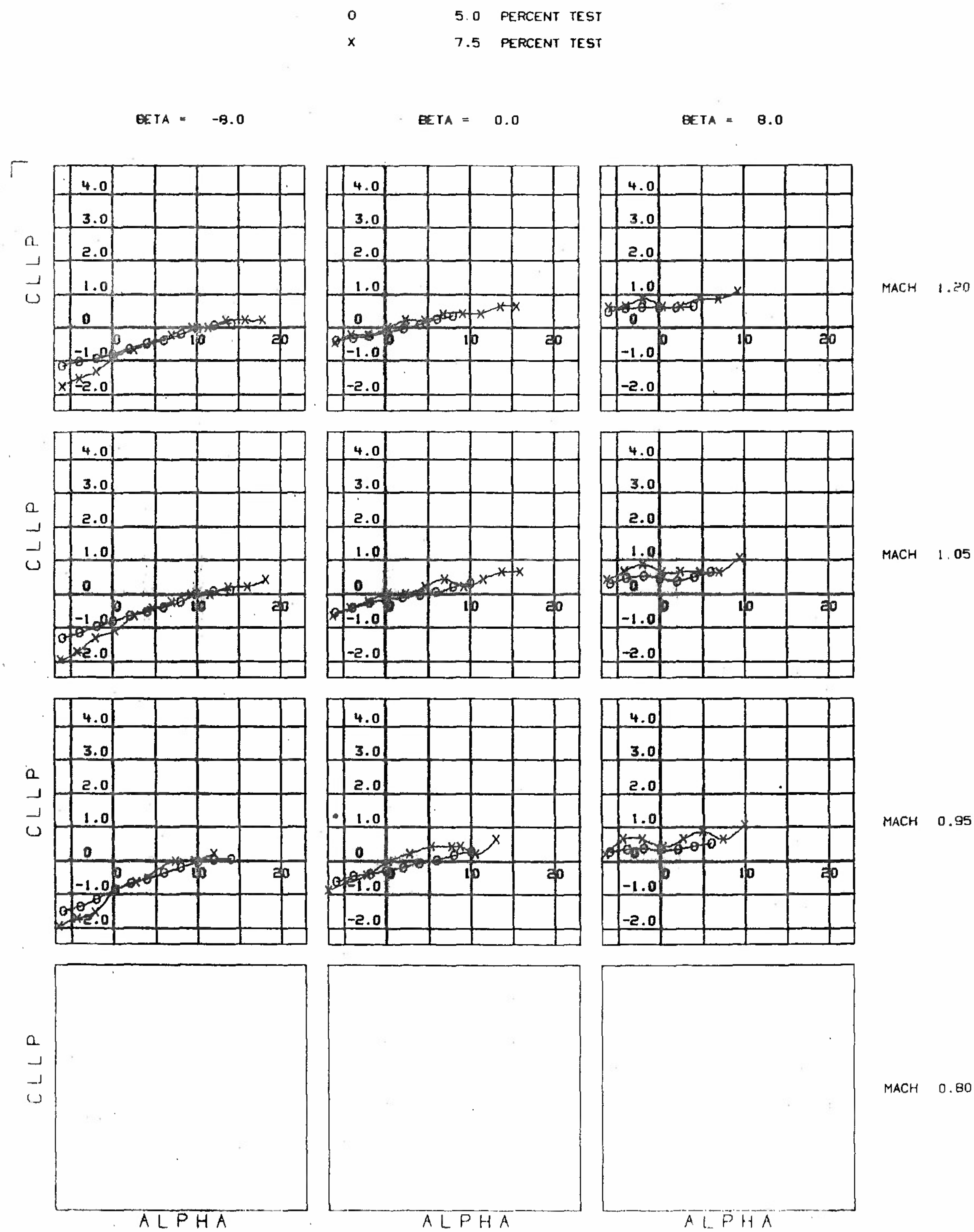


Figure 22. Configuration 1 - CLLP vs ALPHA

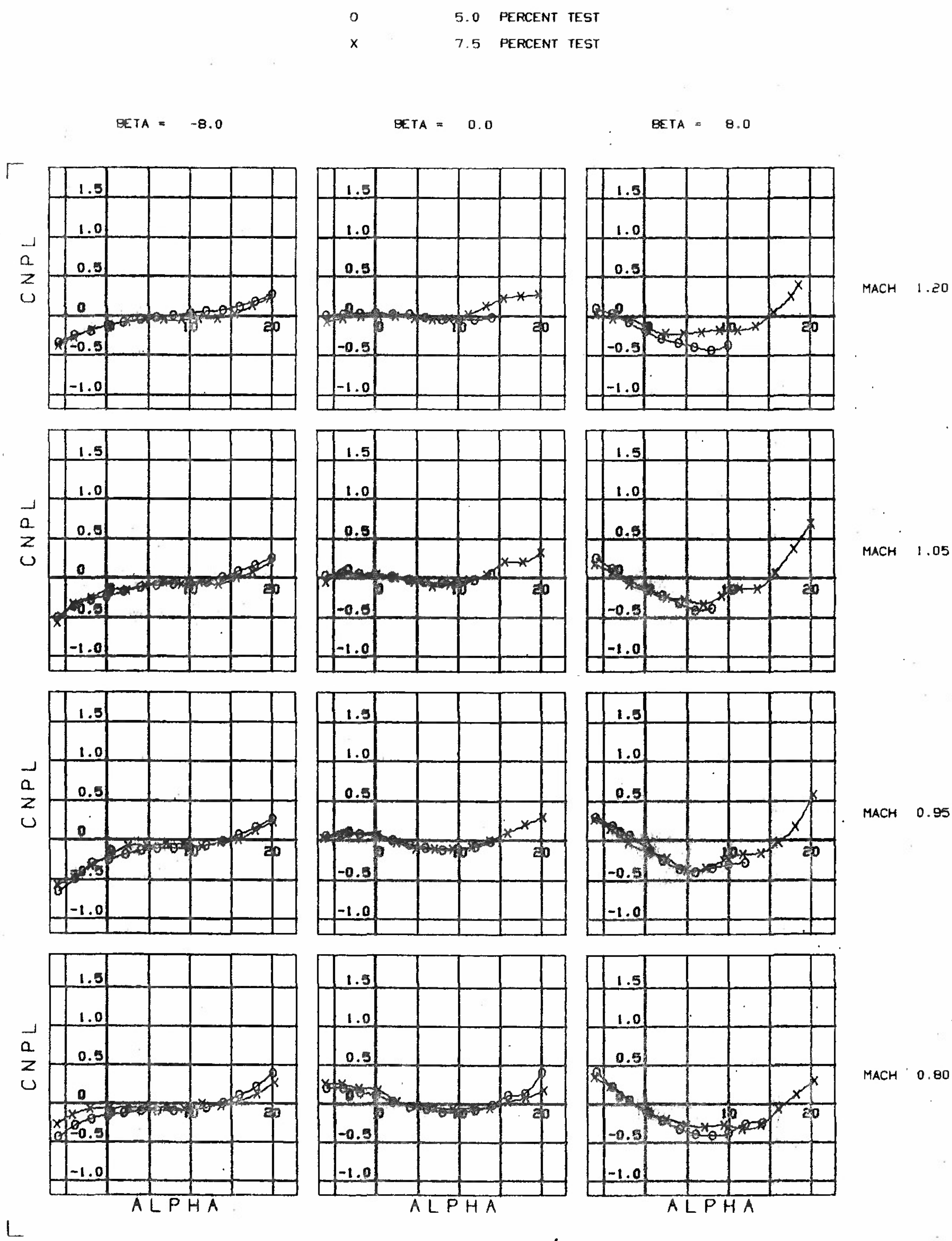


Figure 23. Configuration 2 - CNPL vs ALPHA

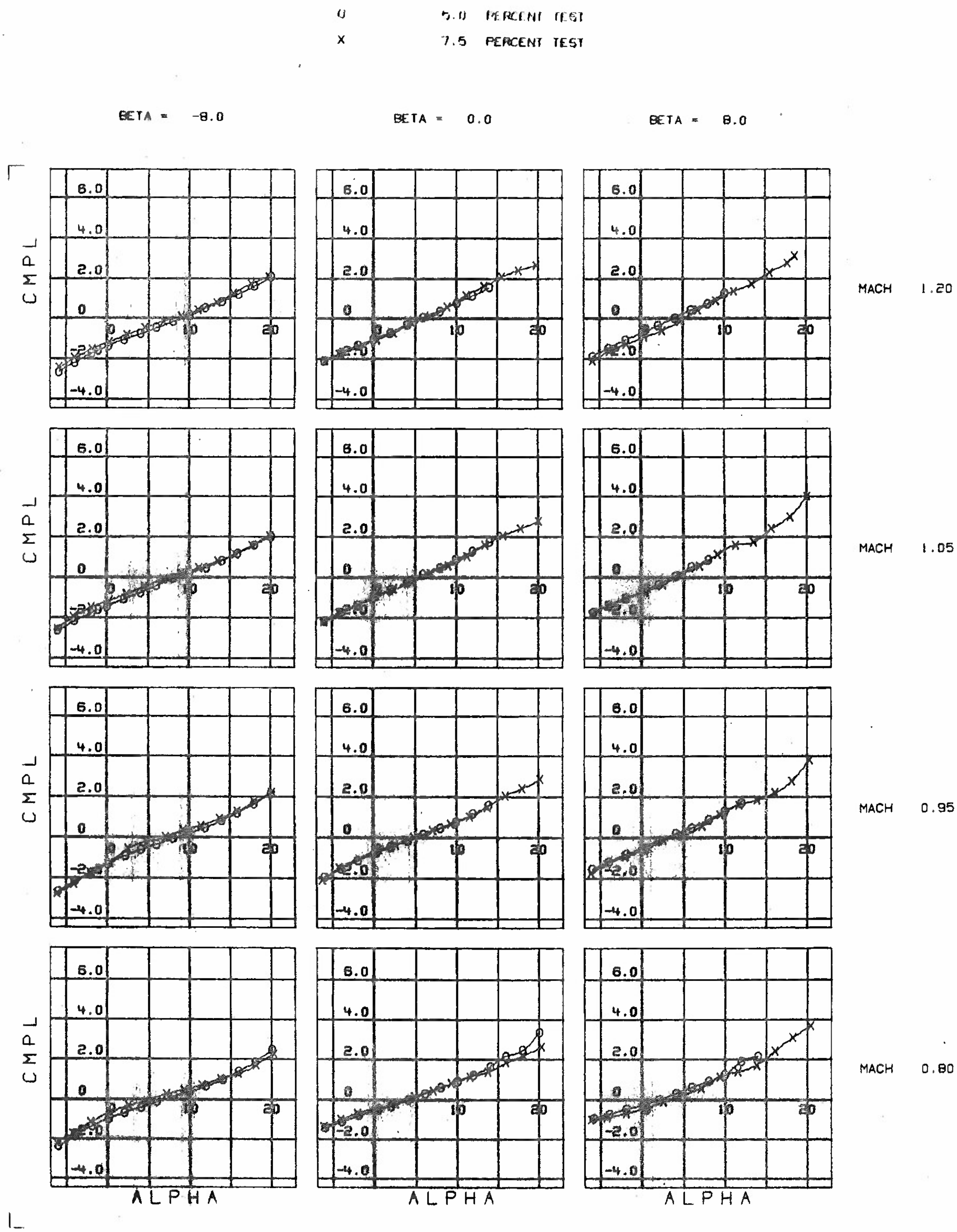


Figure 24. Configuration 2 - CMPL vs ALPHA

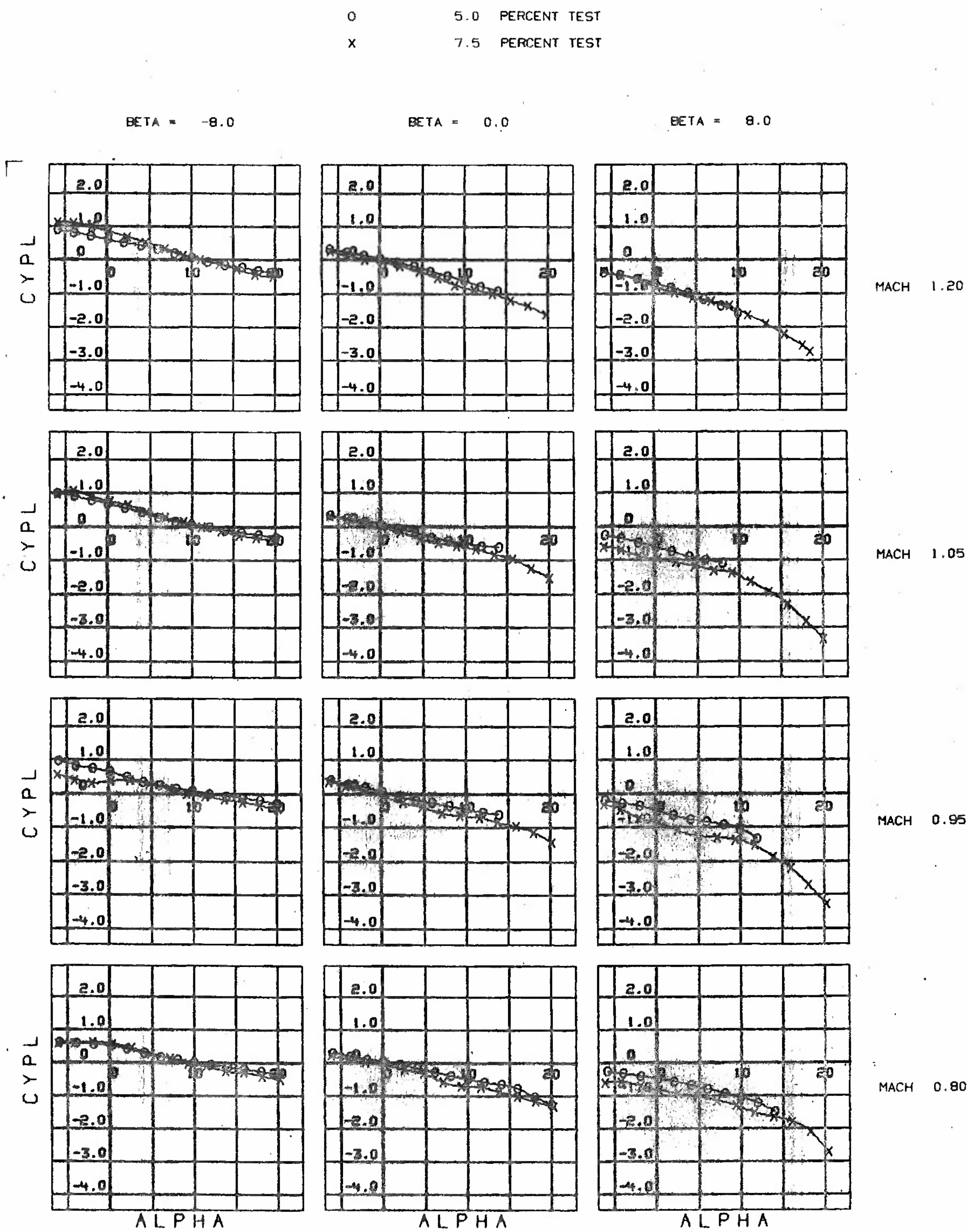


Figure 25. Configuration 2 - CYPL vs ALPHA

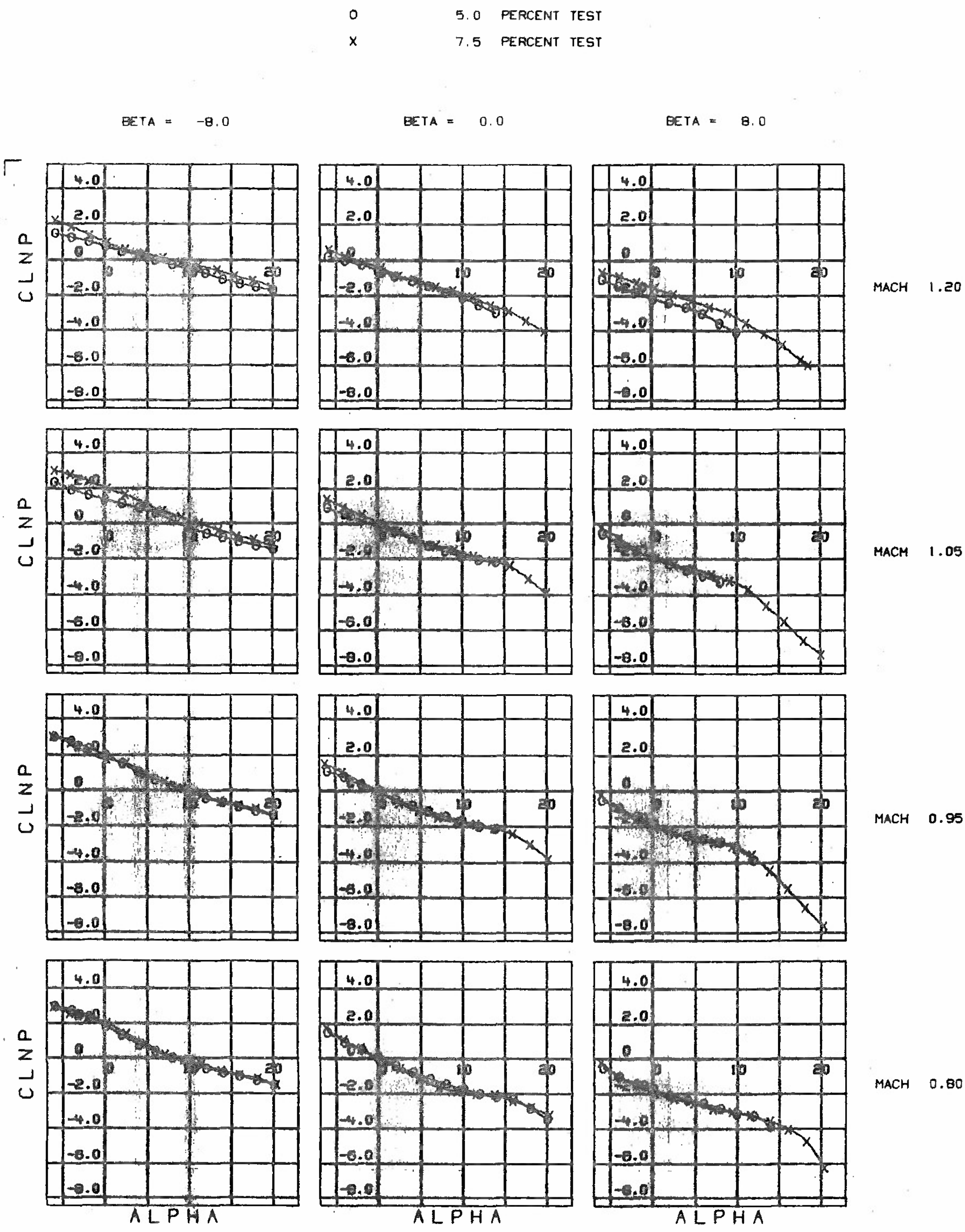


Figure 26. Configuration 2 - CLNP vs ALPHA

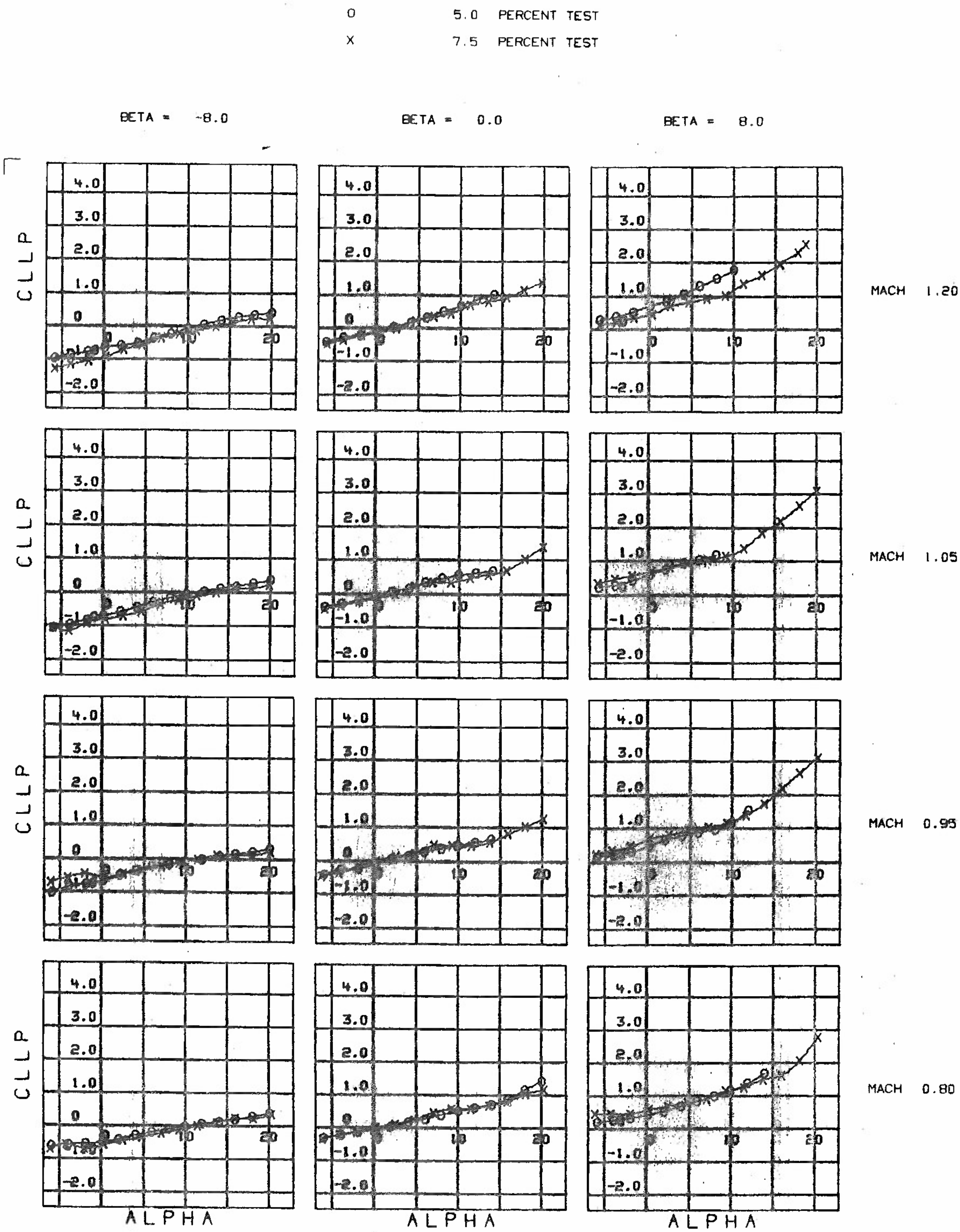


Figure 27. Configuration 2 - CLLP vs ALPHA

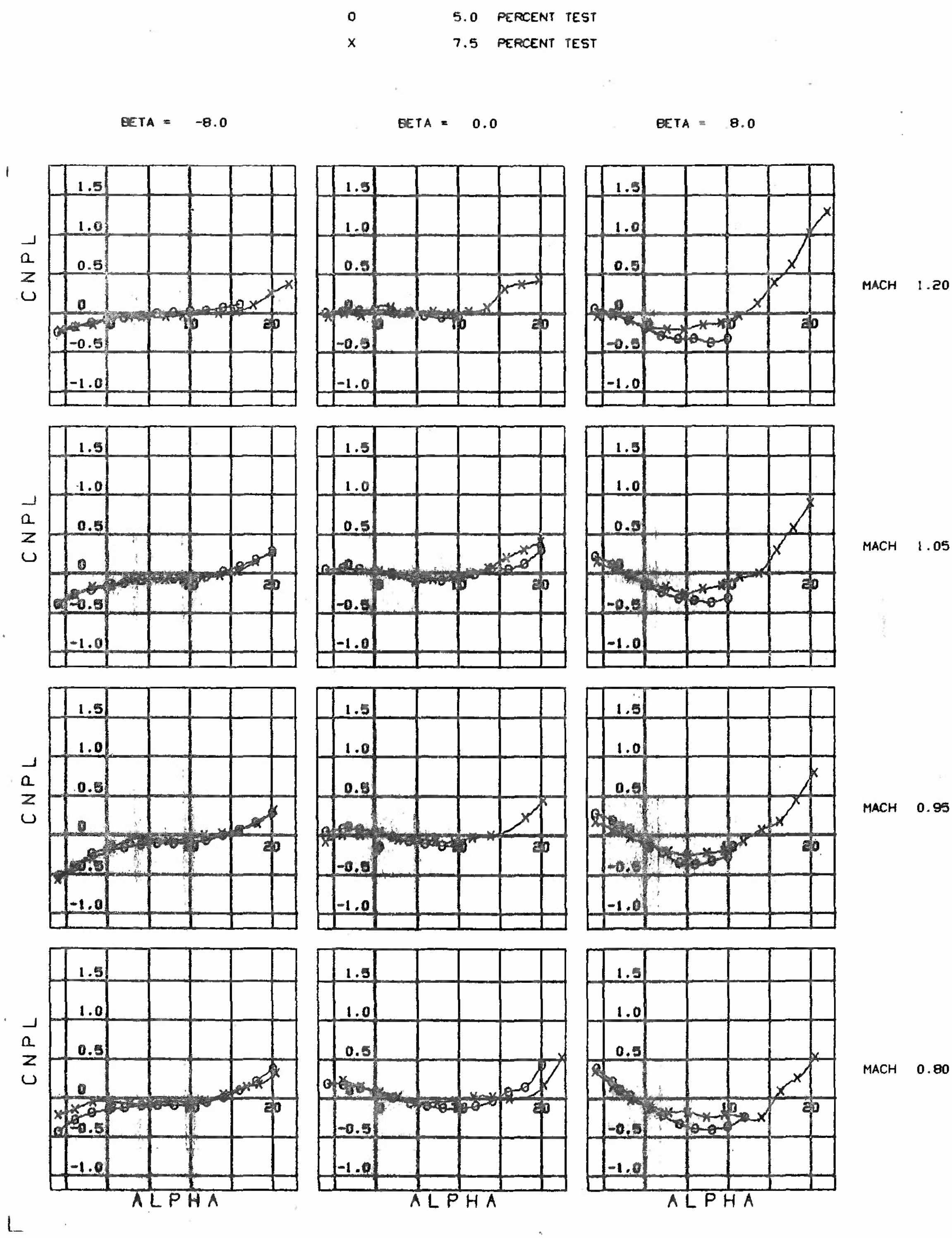


Figure 28, Configuration 3 - CNPL vs ALPHA

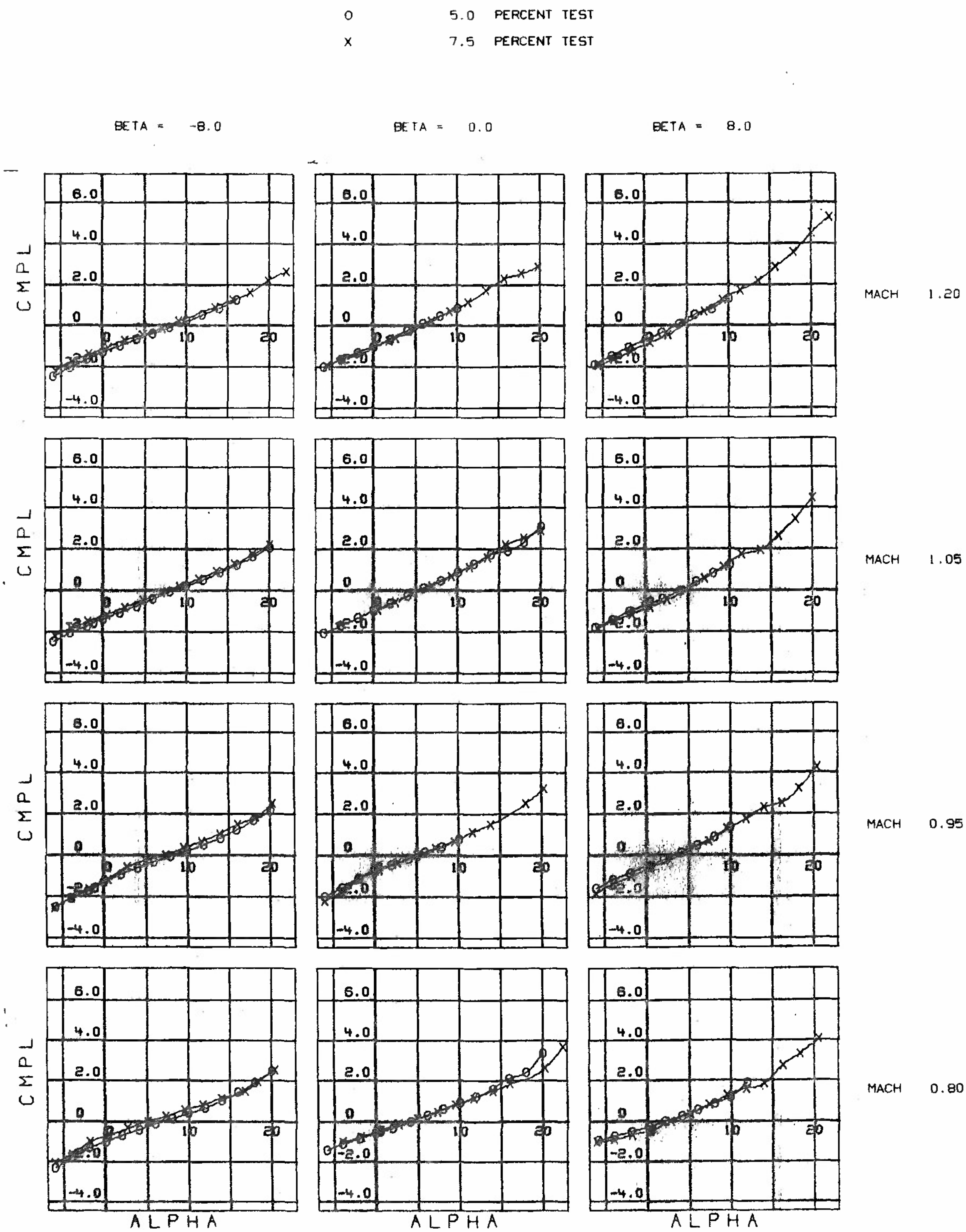


Figure 29. Configuration 3 - CMPL vs ALPHA

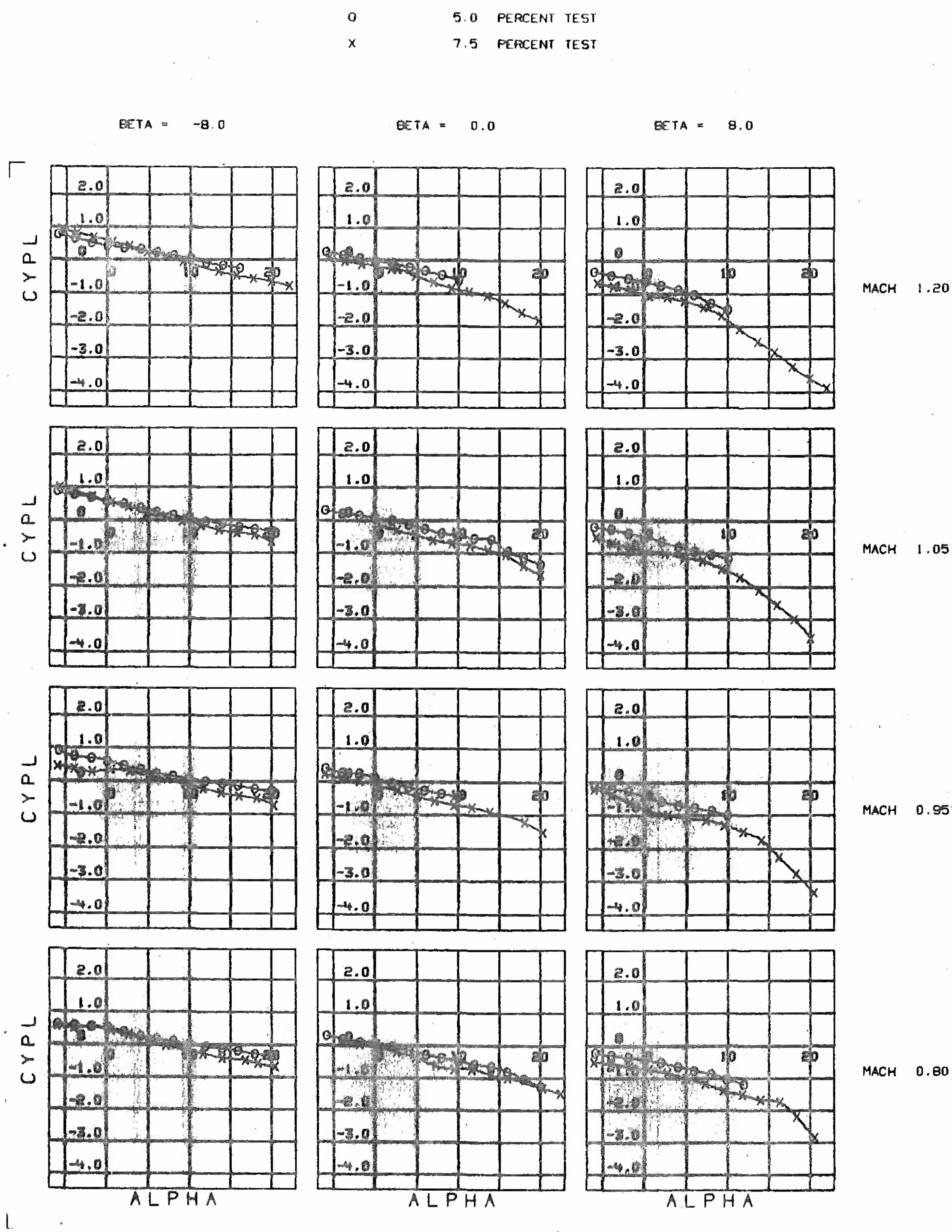


Figure 30. Configuration 3 - CYPL vs ALPHA

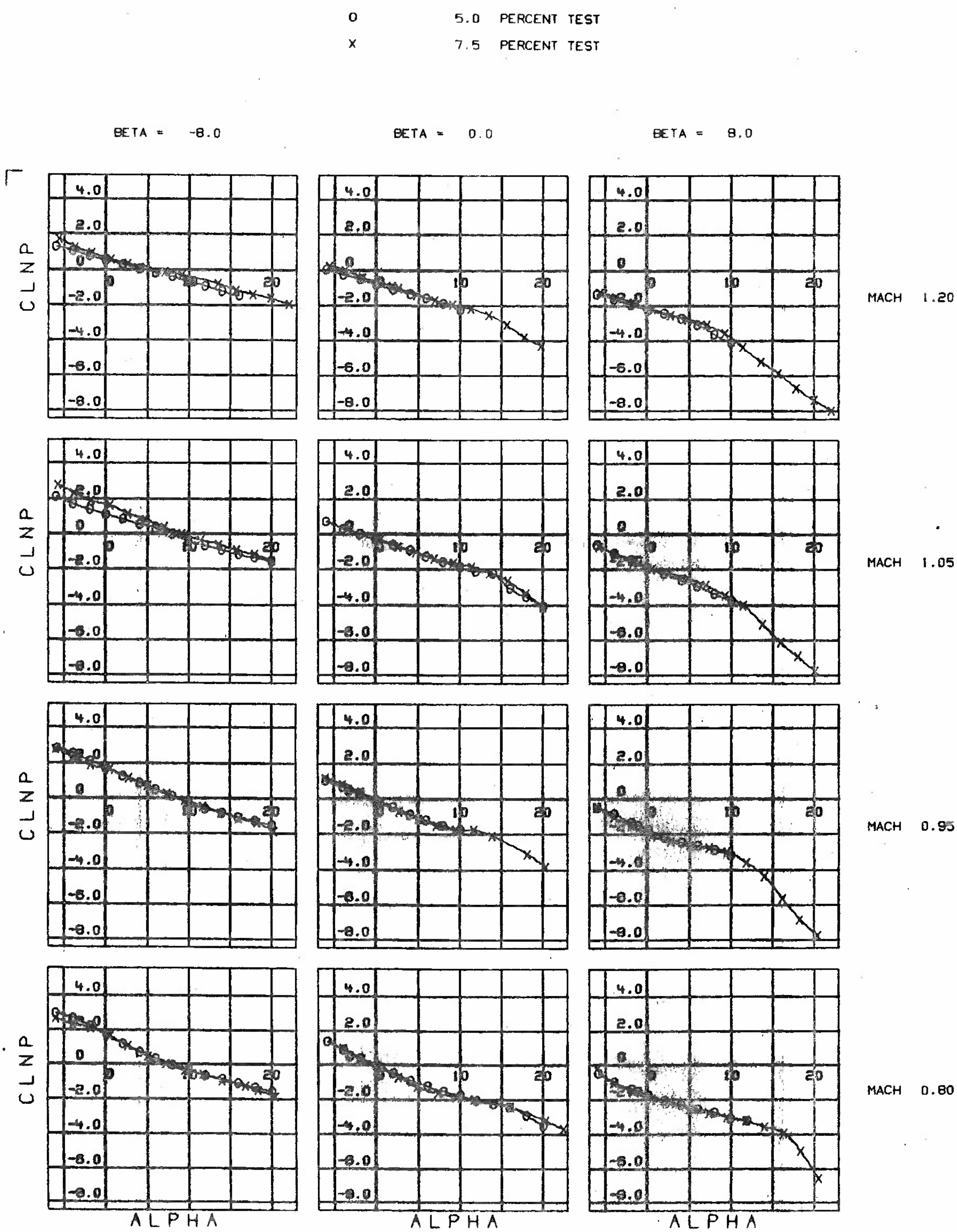


Figure 31. Configuration 3 - CLNP vs ALPHA

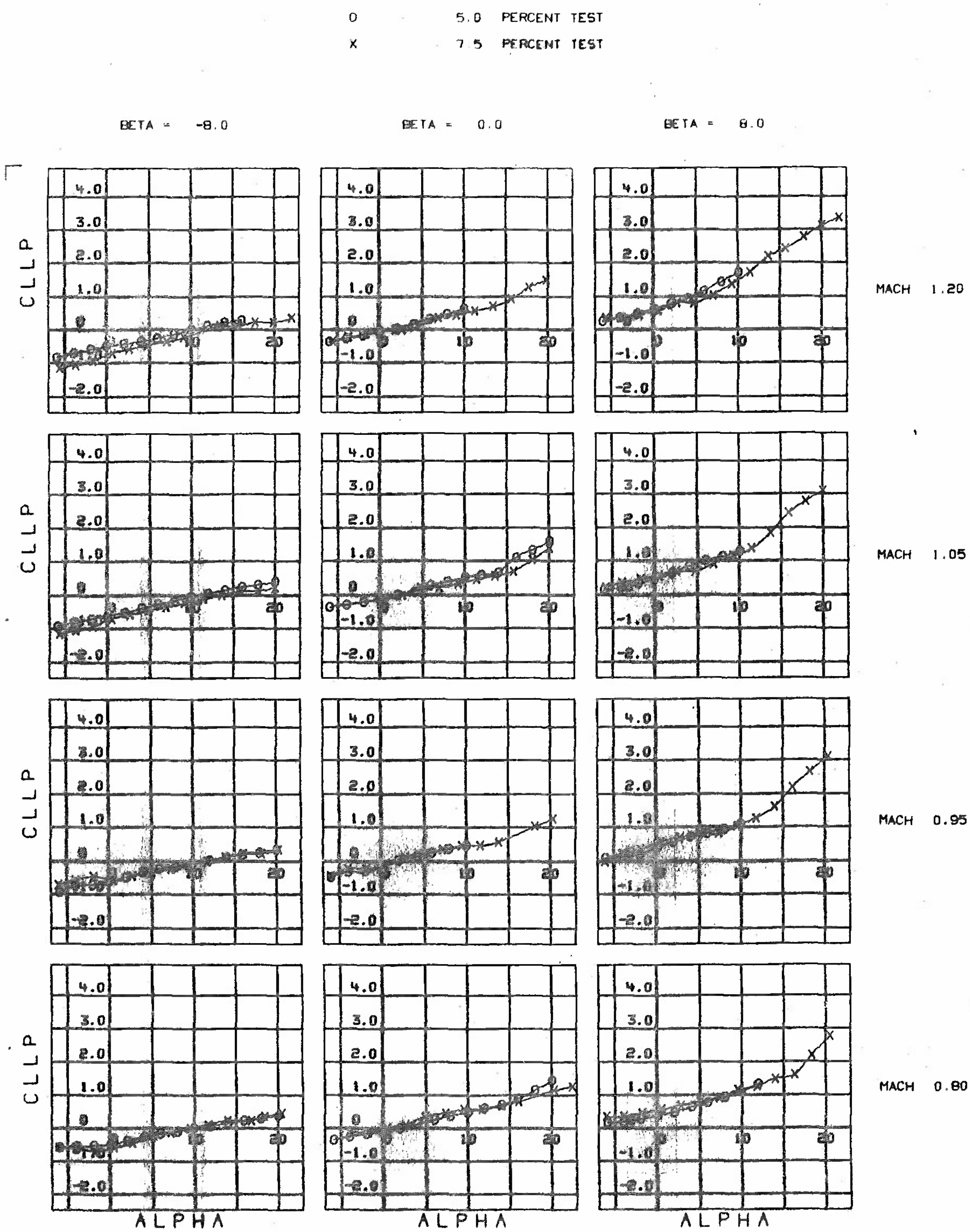


Figure 32. Configuration 3 - CLLP vs ALPHA

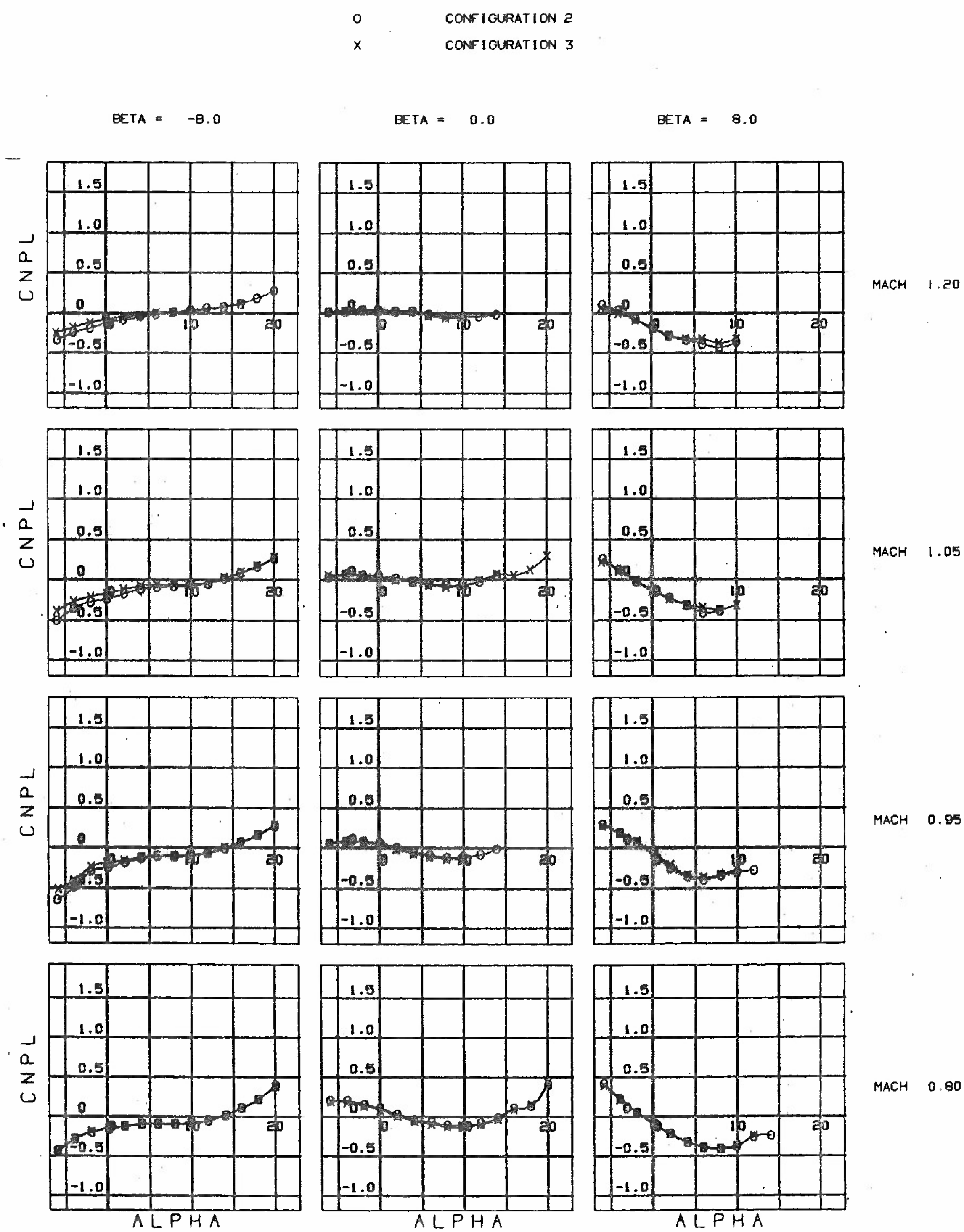


Figure 33. Configuration 2 vs 3 - CNPL vs ALPHA

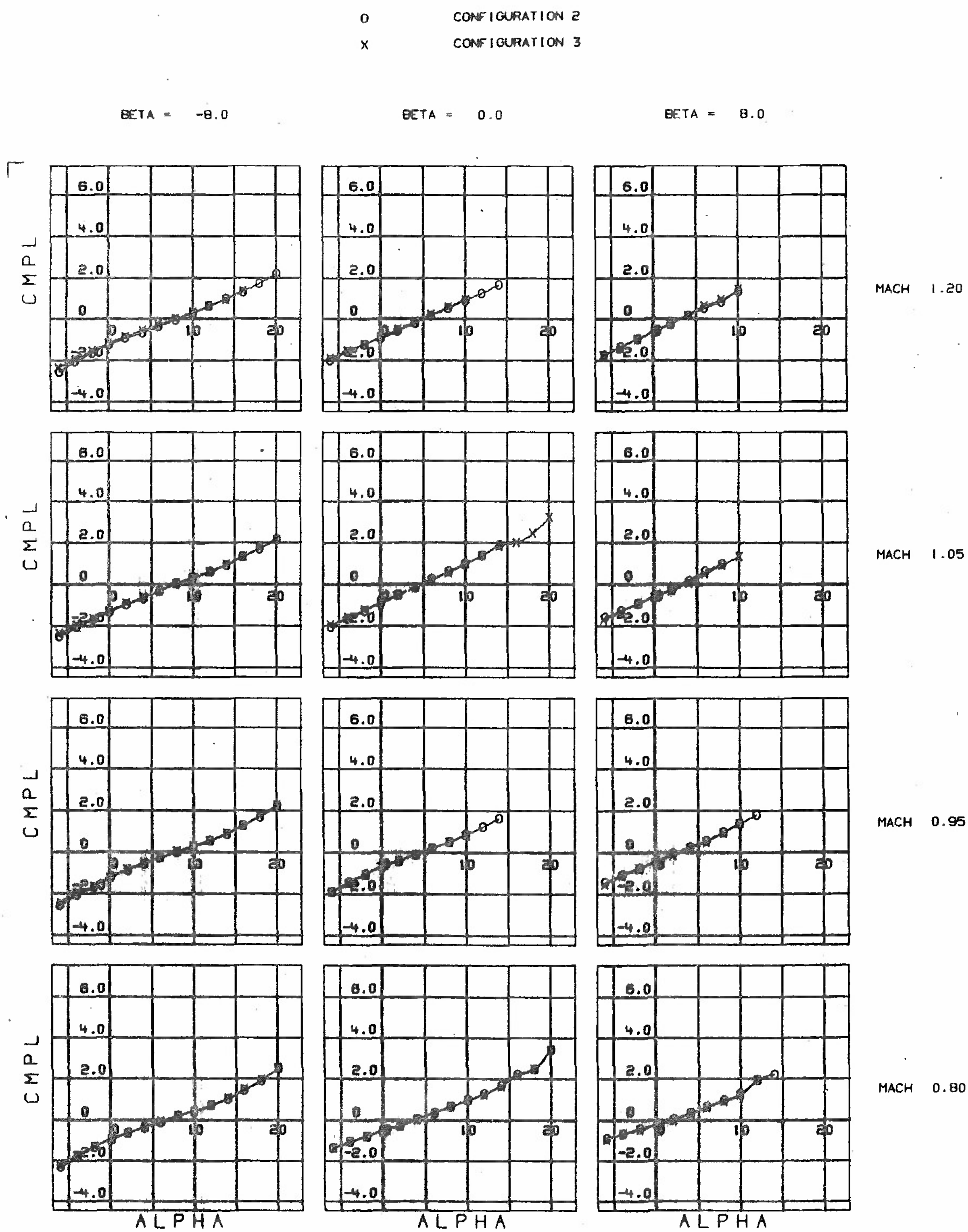


Figure 34. Configuration 2 vs 3 - CMPL vs ALPHA

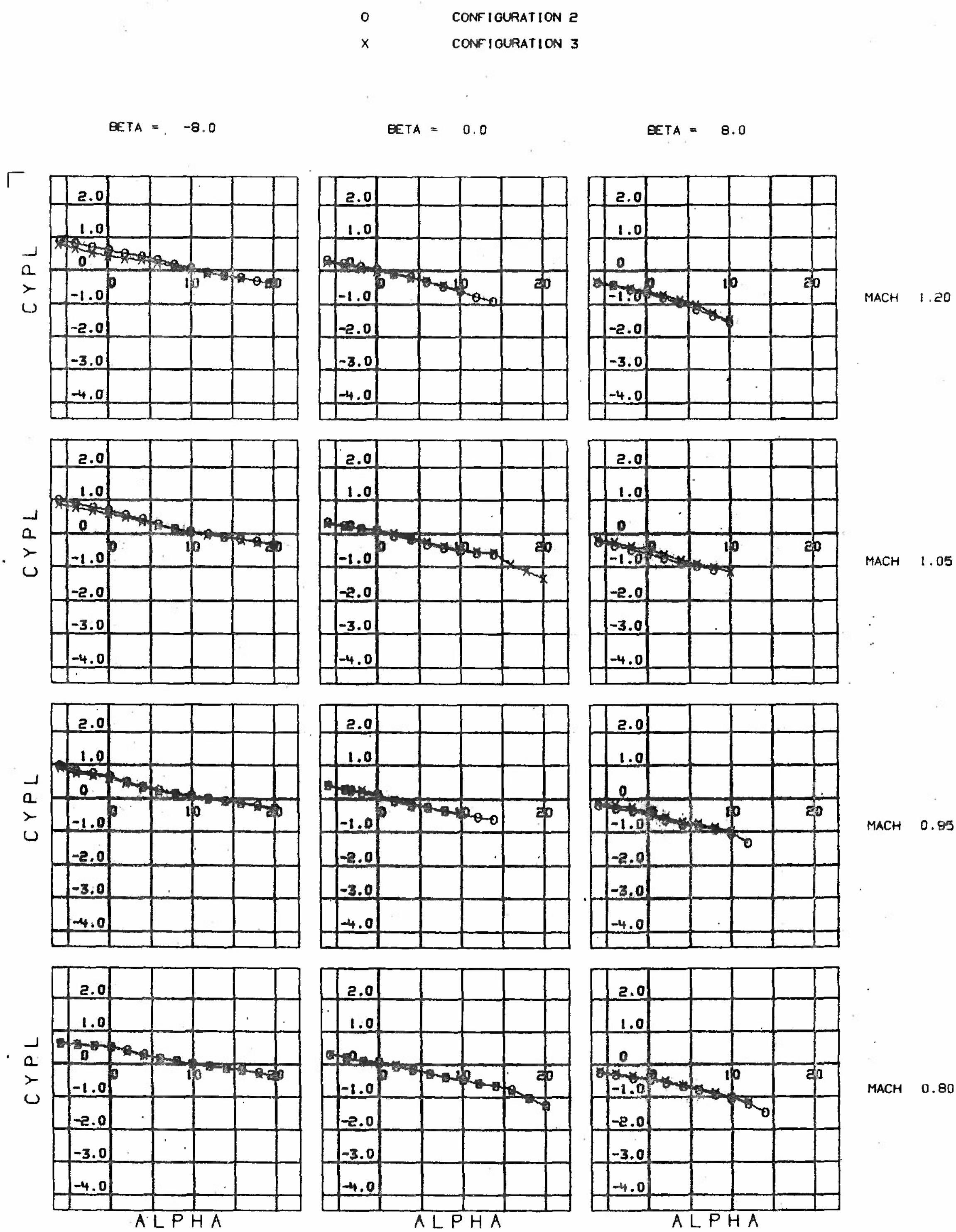


Figure 35. Configuration 2 vs 3 - CYPL vs ALPHA

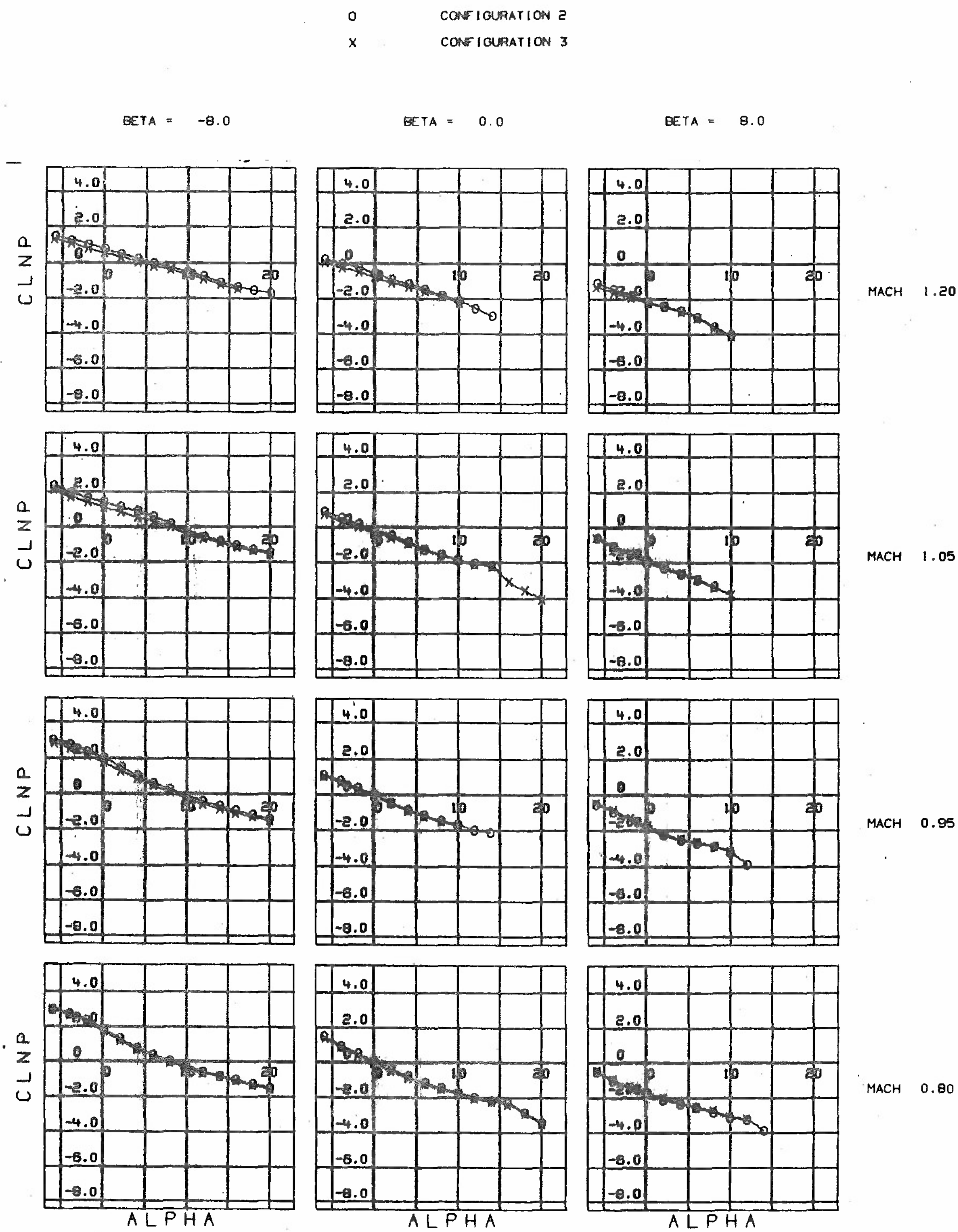


Figure 36. Configuration 2 vs 3 - CLNP vs ALPHA

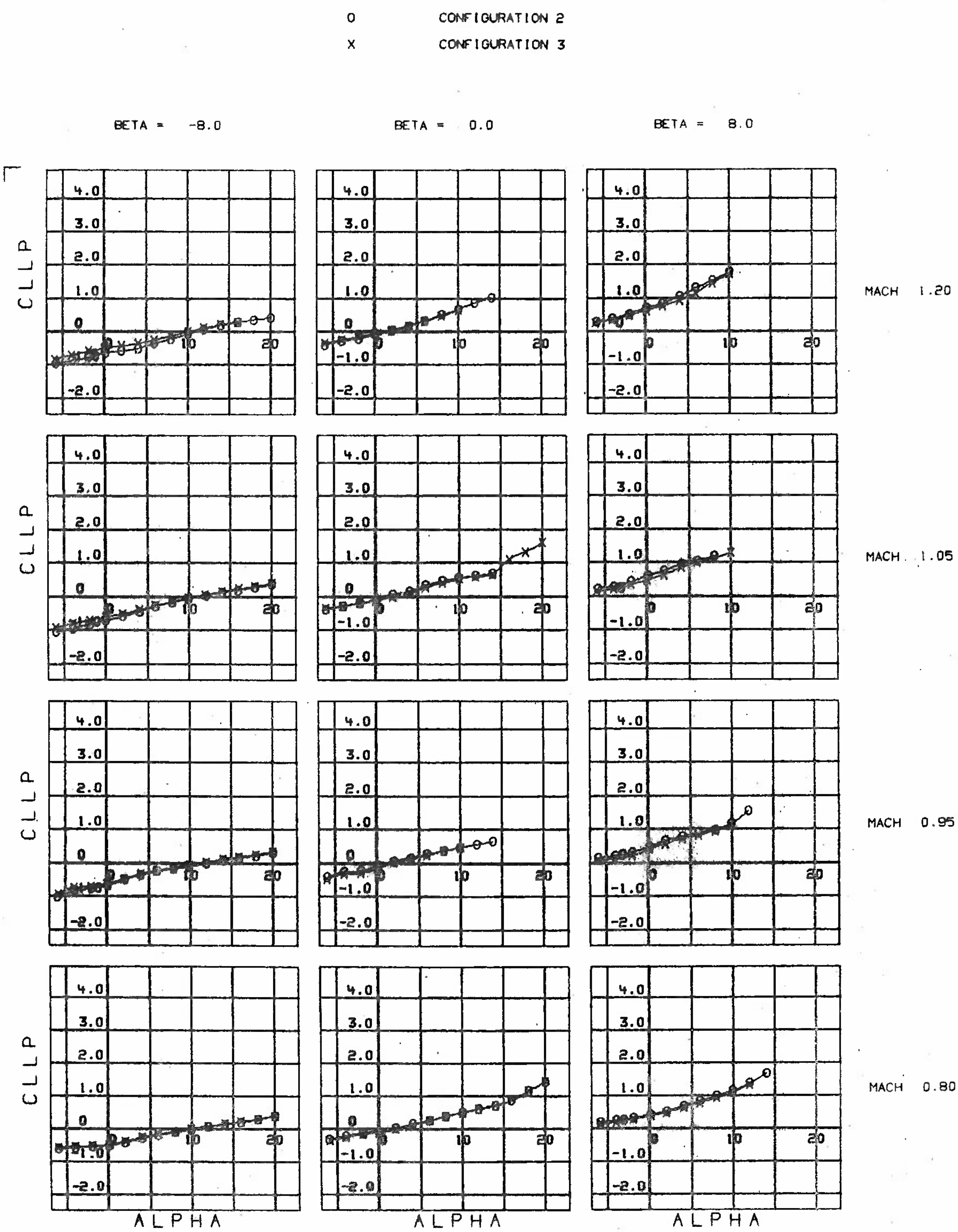


Figure 37. Configuration 2 vs 3 - CLLP vs ALPHA

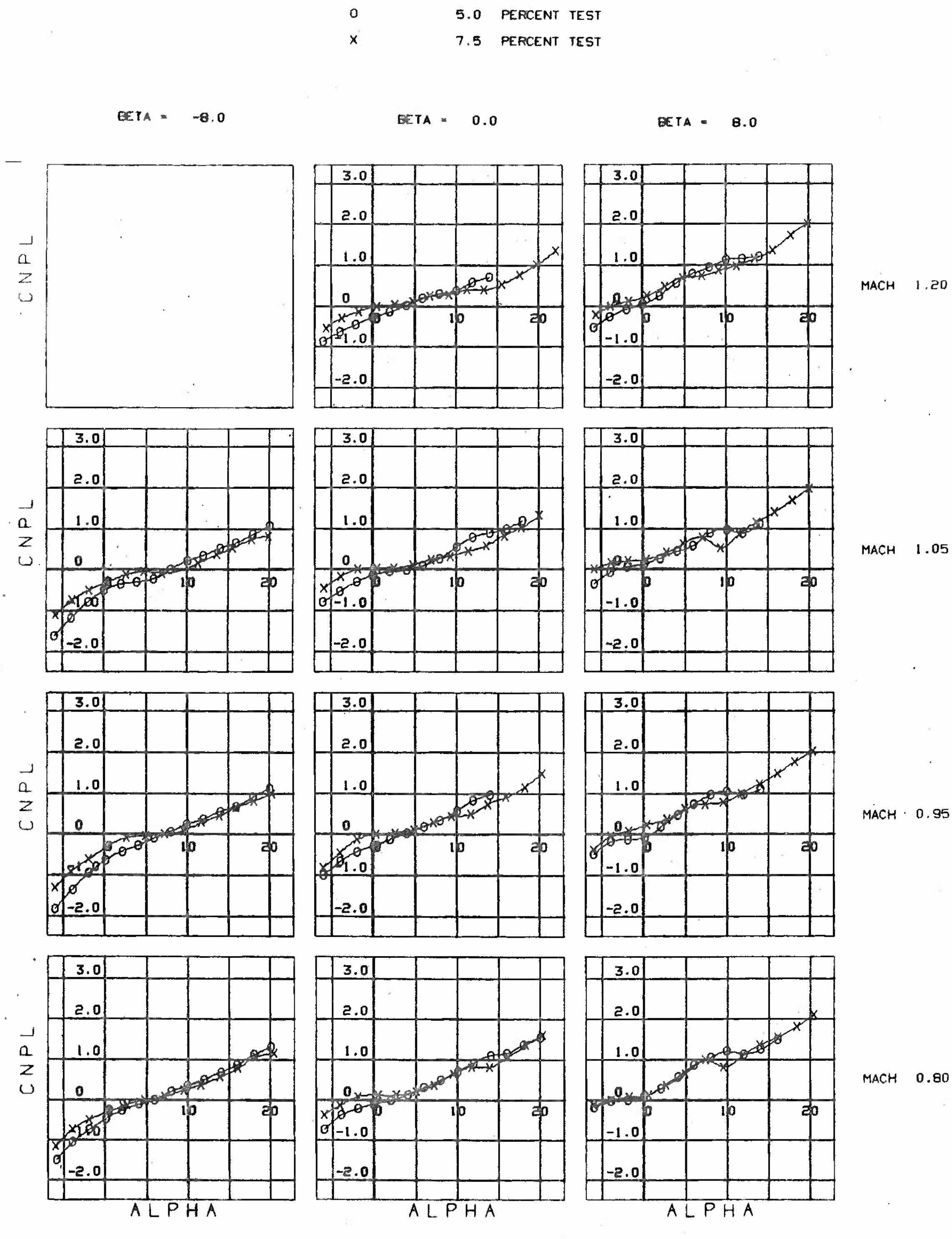


Figure 38. Configuration 4 - CNPL vs ALPHA

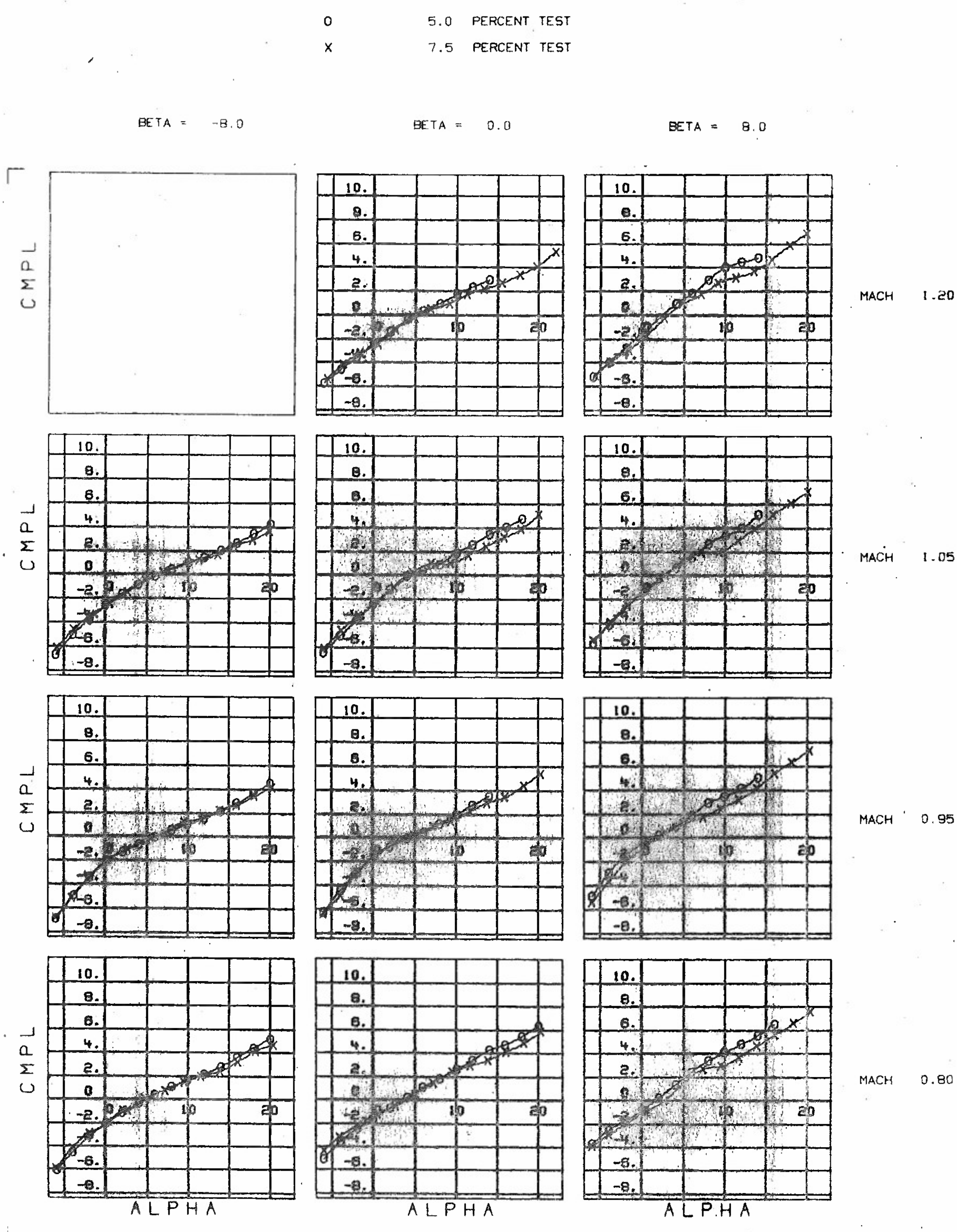


Figure 39. Configuration 4 - CMPL vs ALPHA

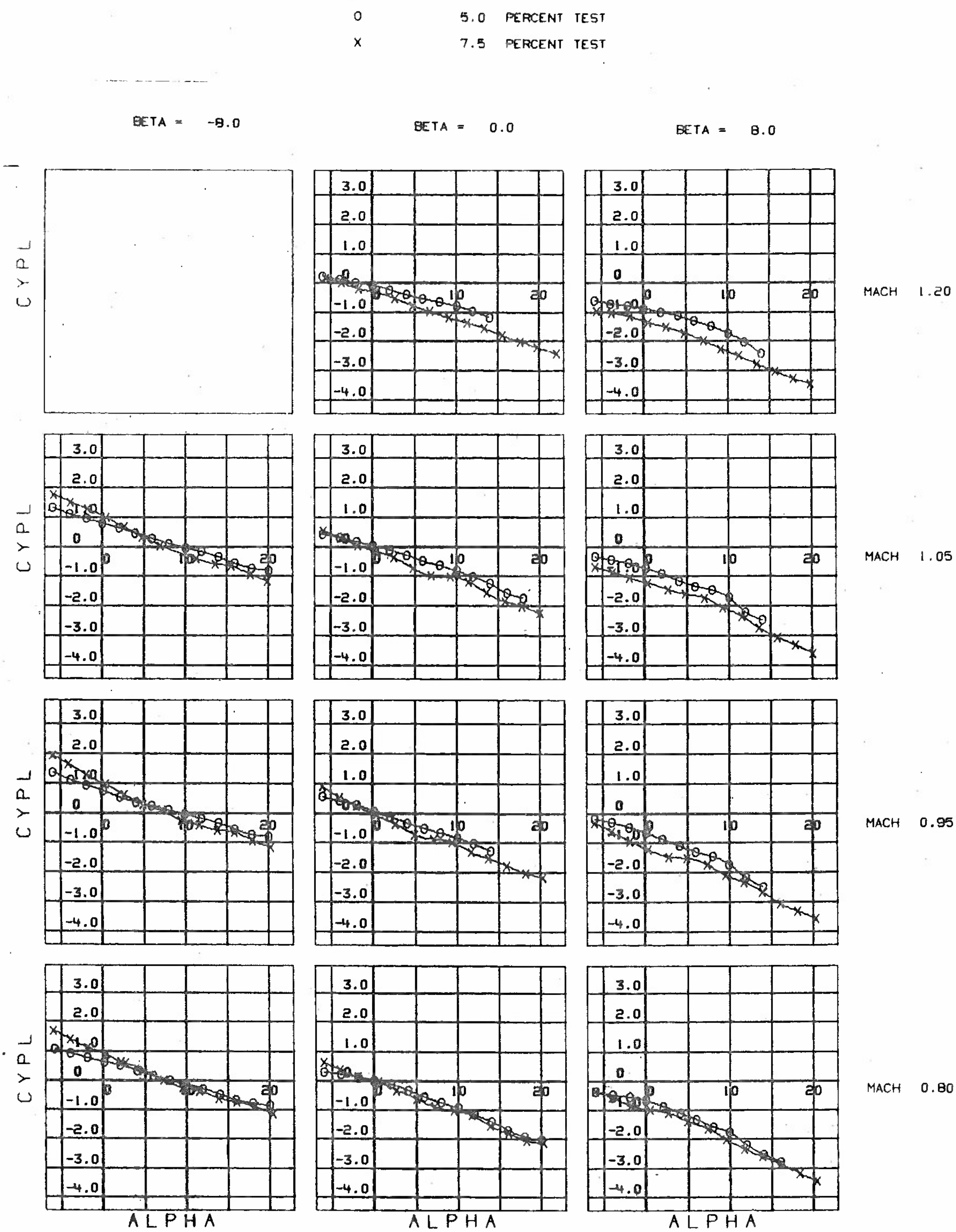


Figure 40. Configuration 4 - CYPL vs ALPHA

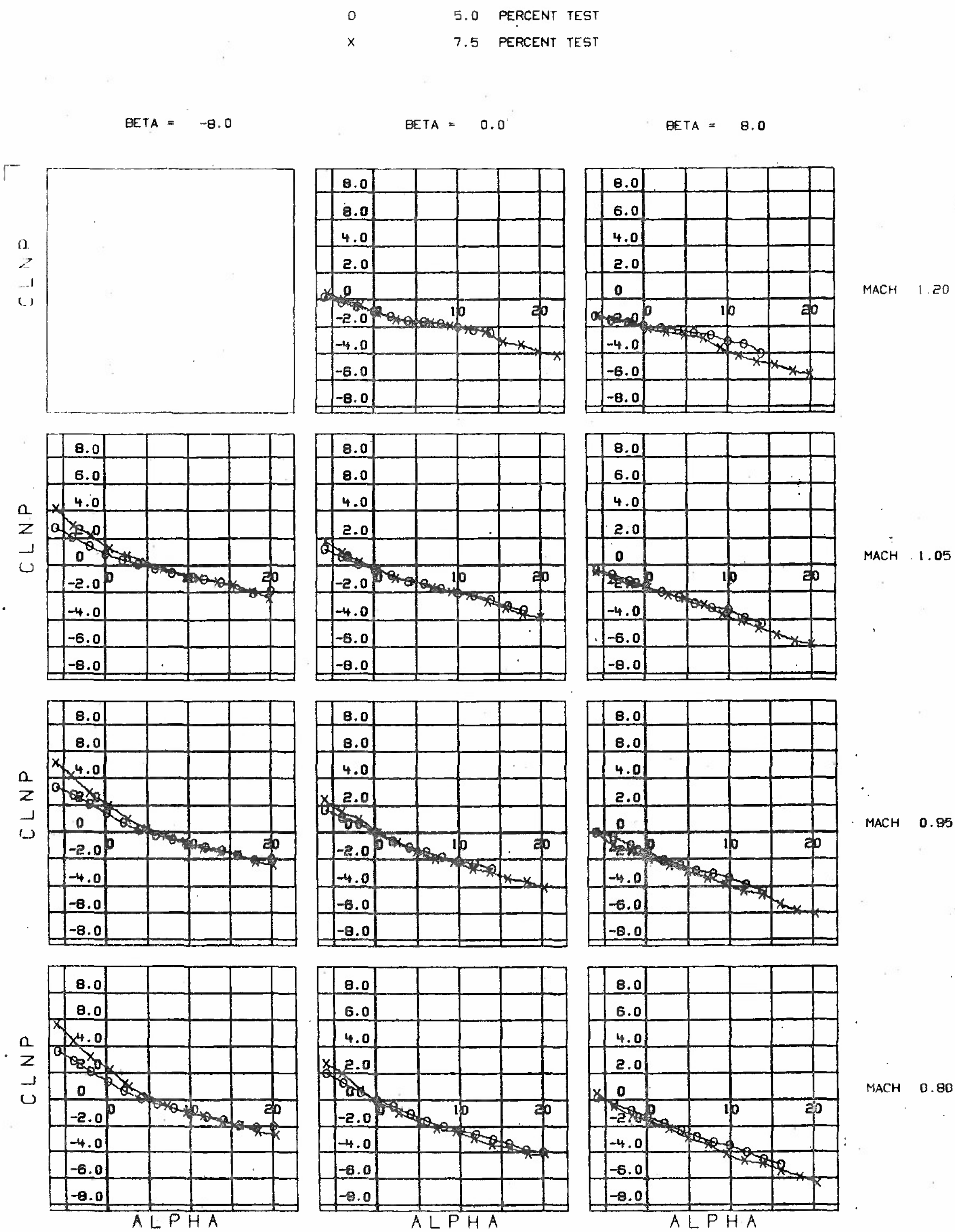


Figure 41. Configuration 4 - CLNP vs ALPHA

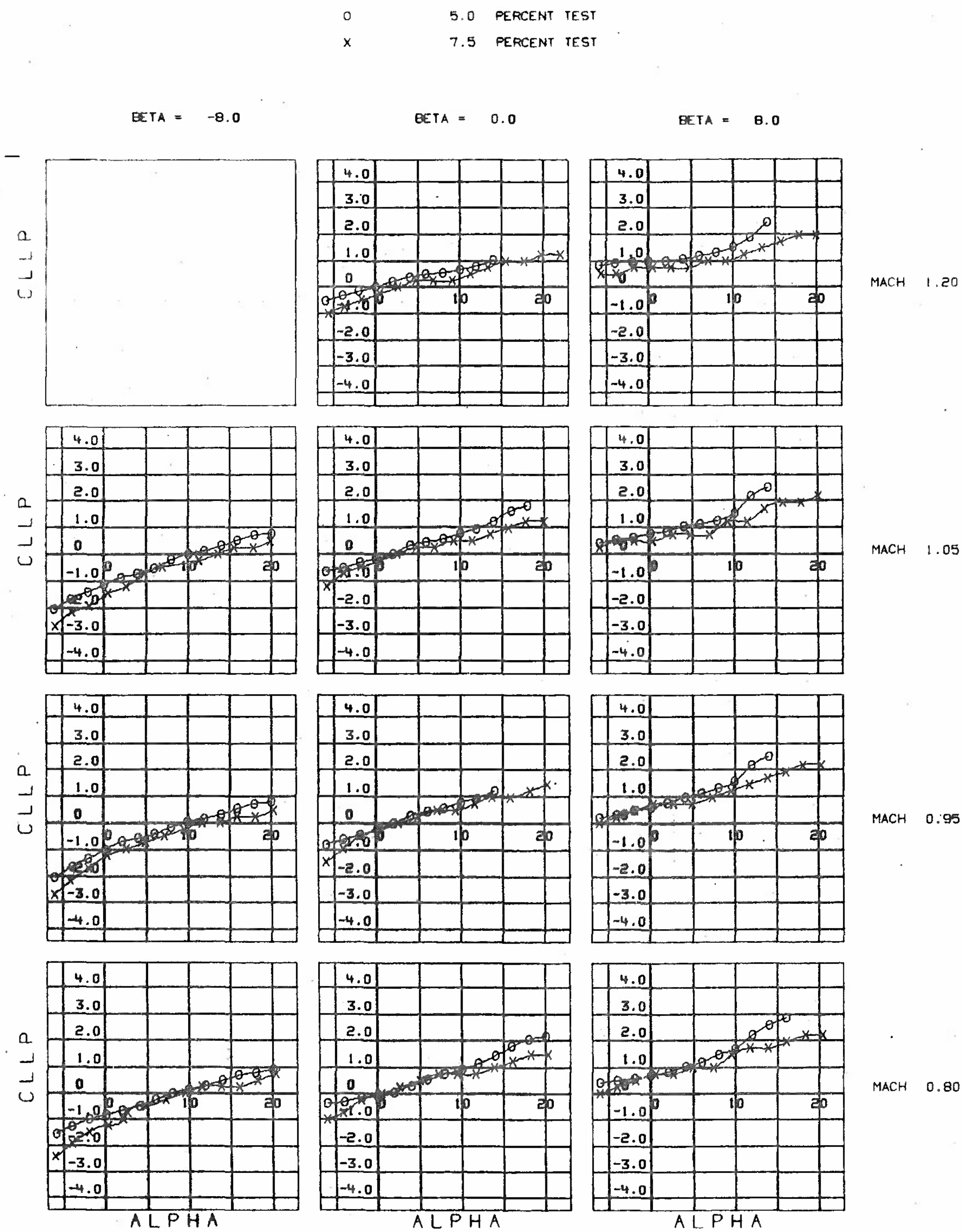


Figure 42. Configuration 4 - CLLP vs ALPHA

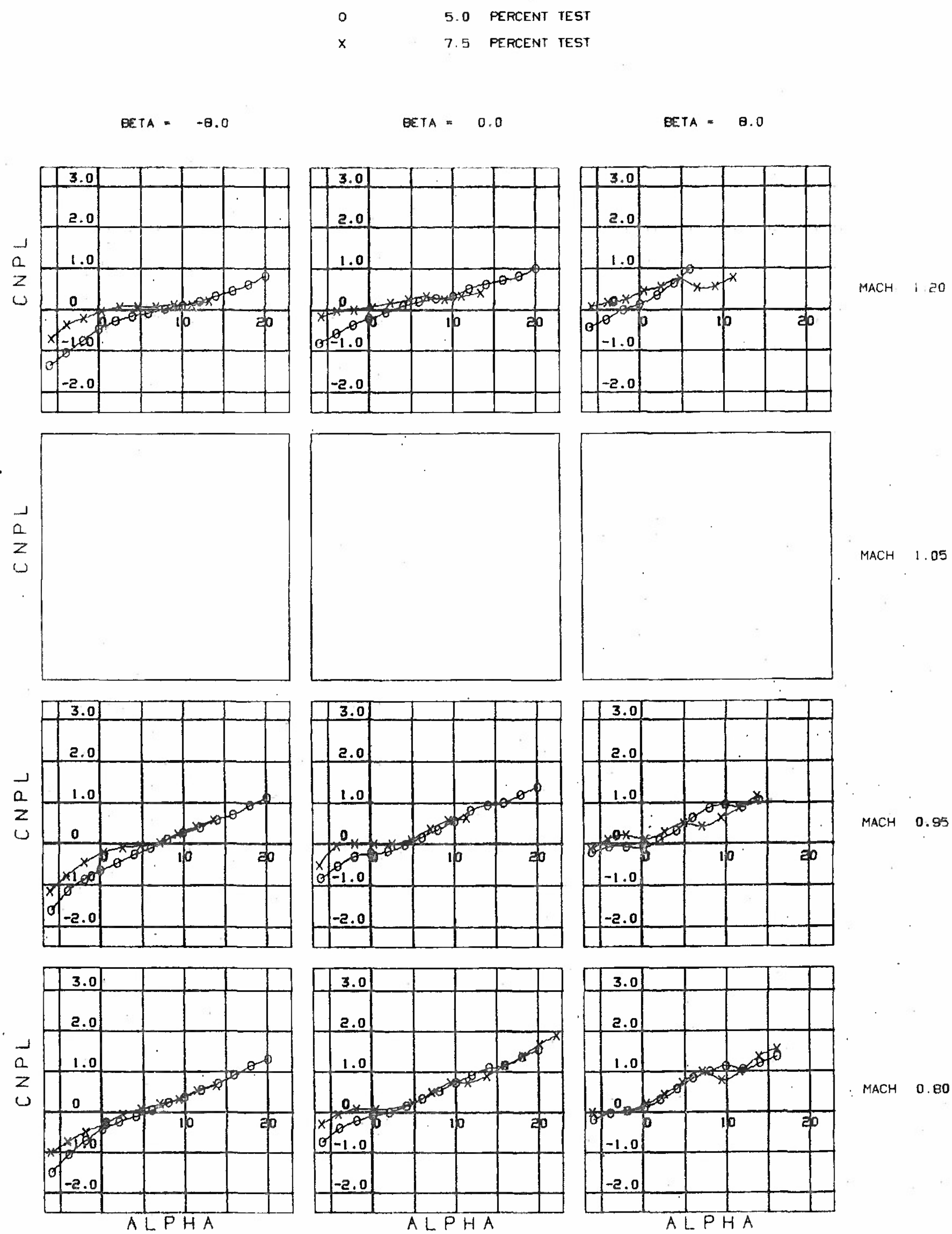


Figure 43. Configuration 5 - CNPL vs ALPHA

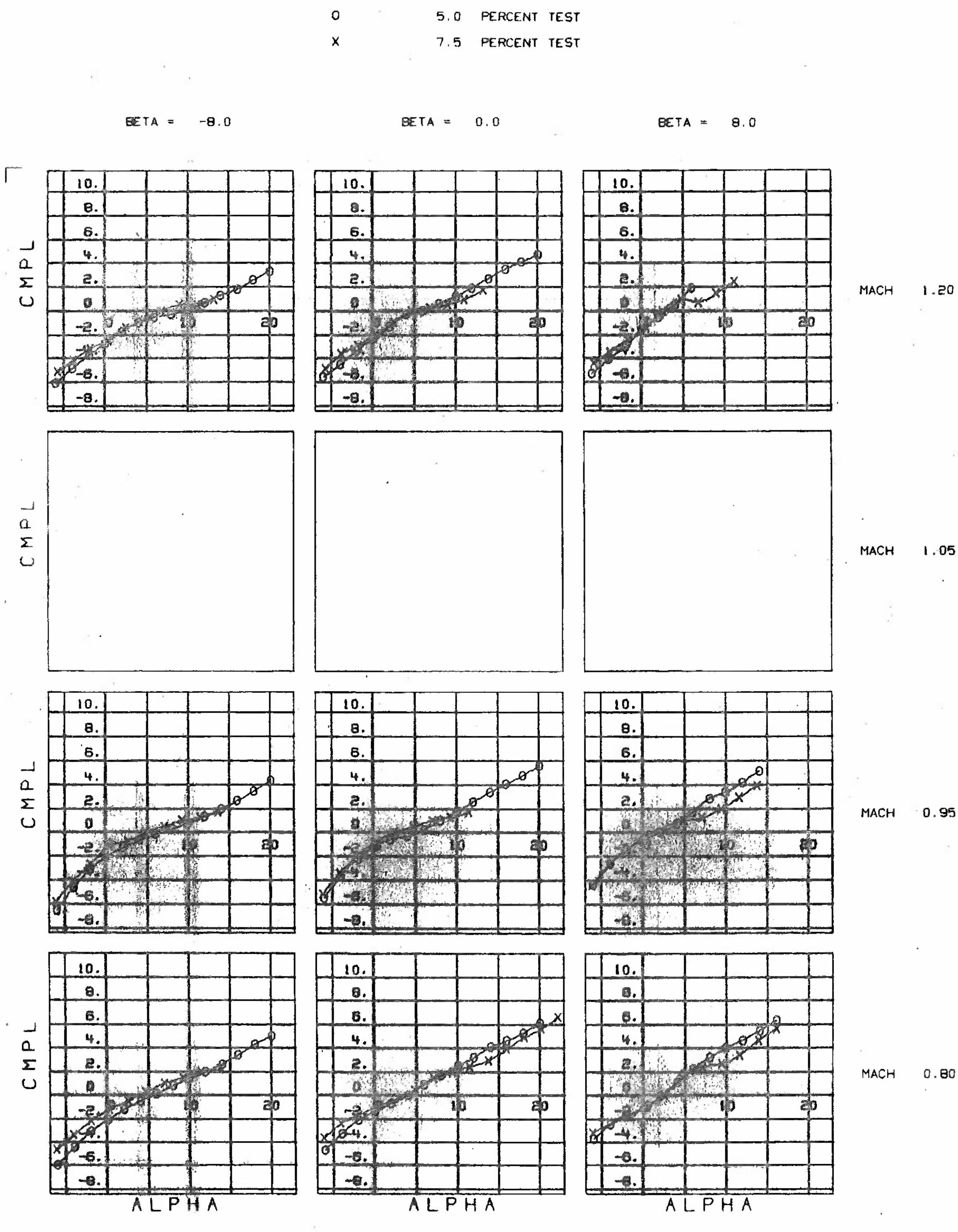


Figure 44. Configuration 5 - CMPL vs ALPHA

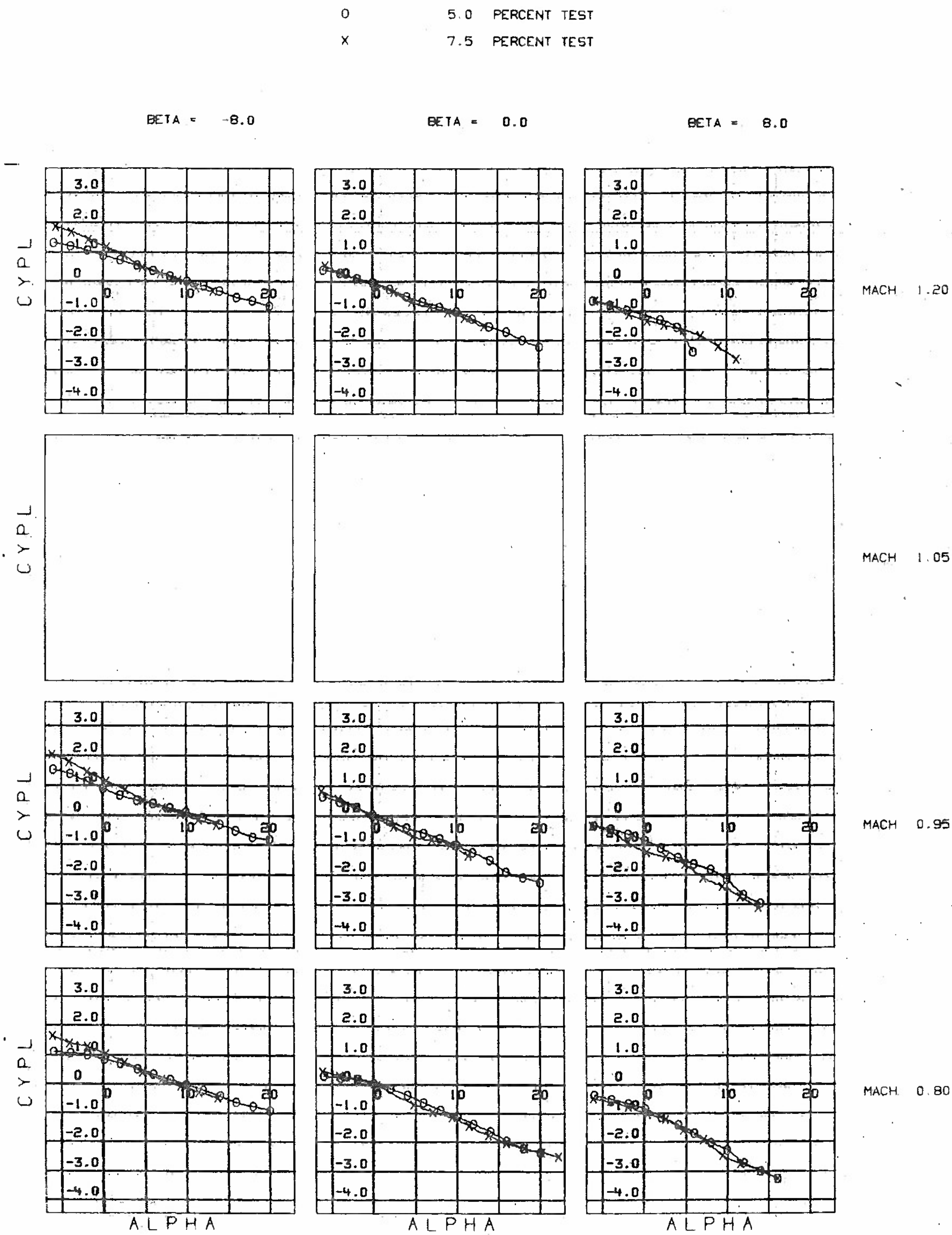


Figure 45, Configuration 5 - CYPL vs ALPHA

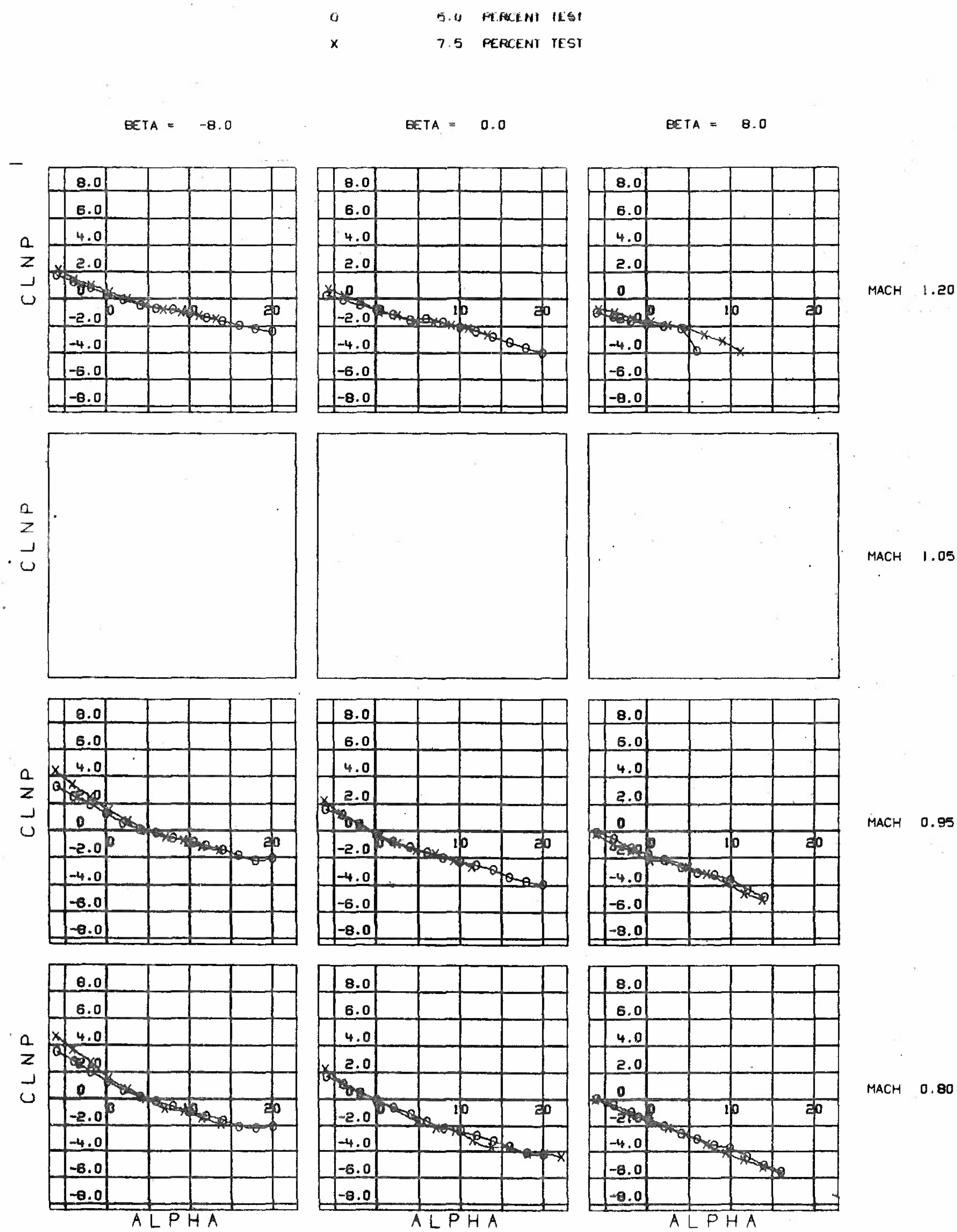


Figure 46. Configuration 5 - CLNP vs ALPHA

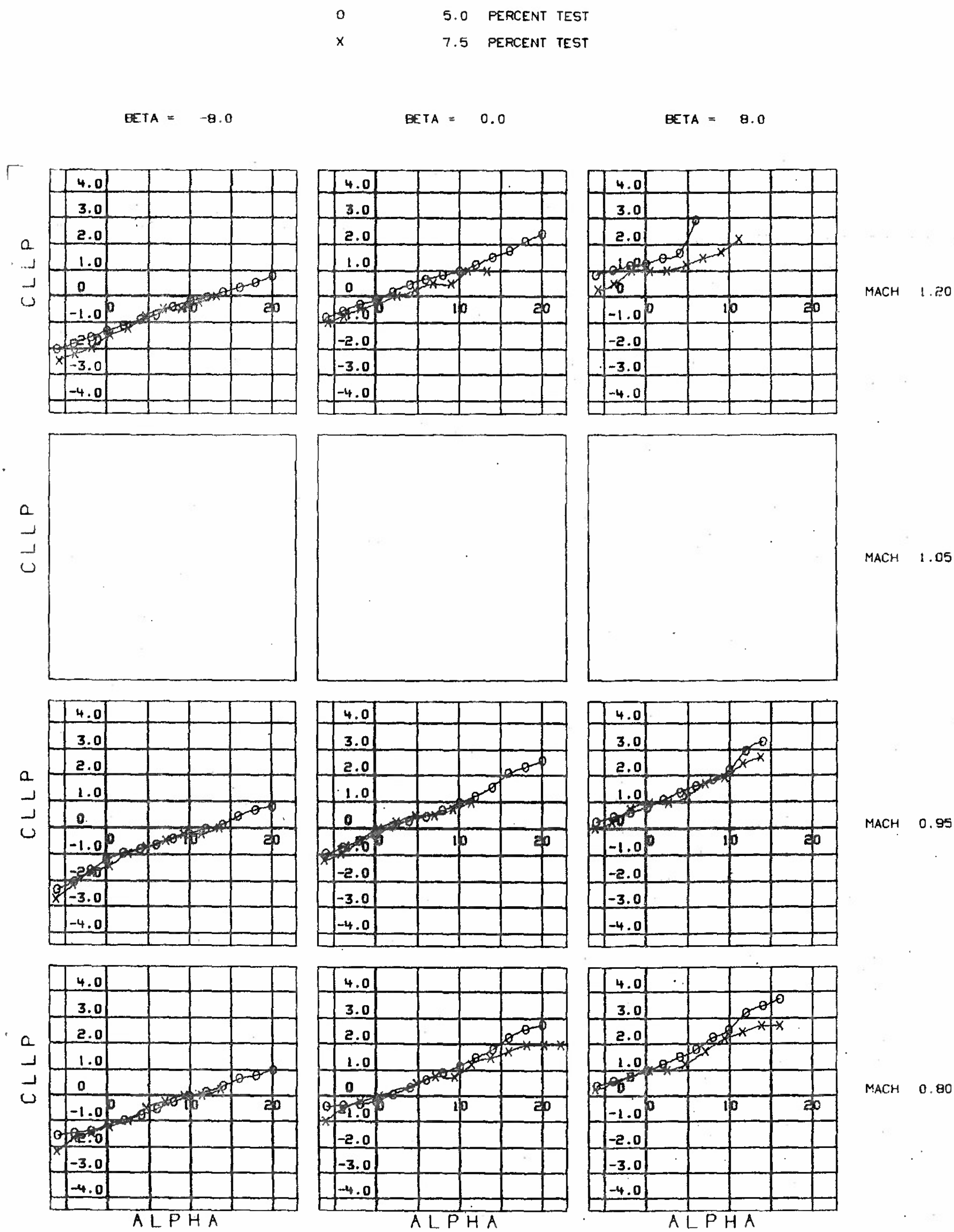


Figure 47. Configuration 5 - CLLP vs ALPHA

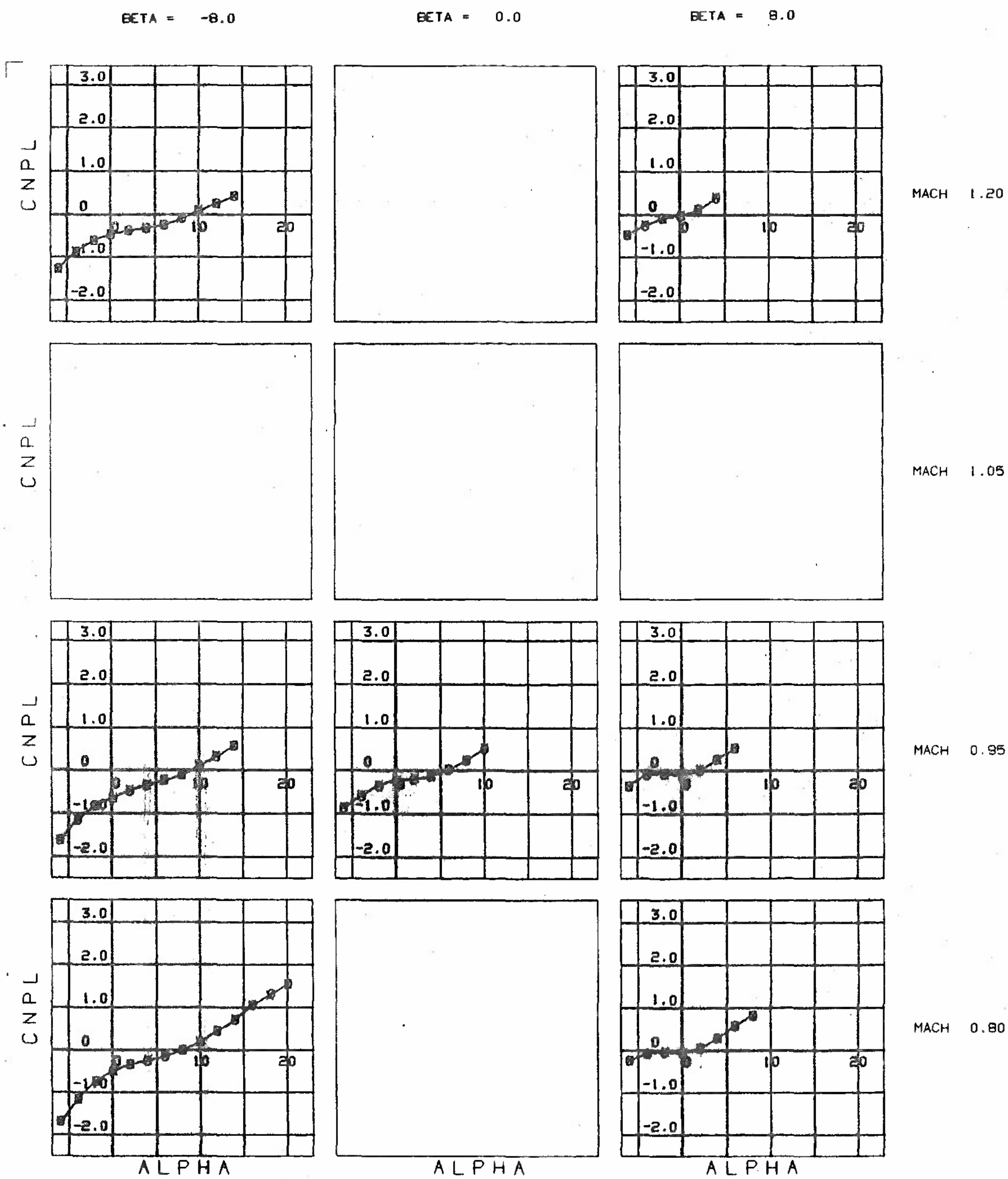


Figure 48, Hysteresis Data - CNPL vs ALPHA

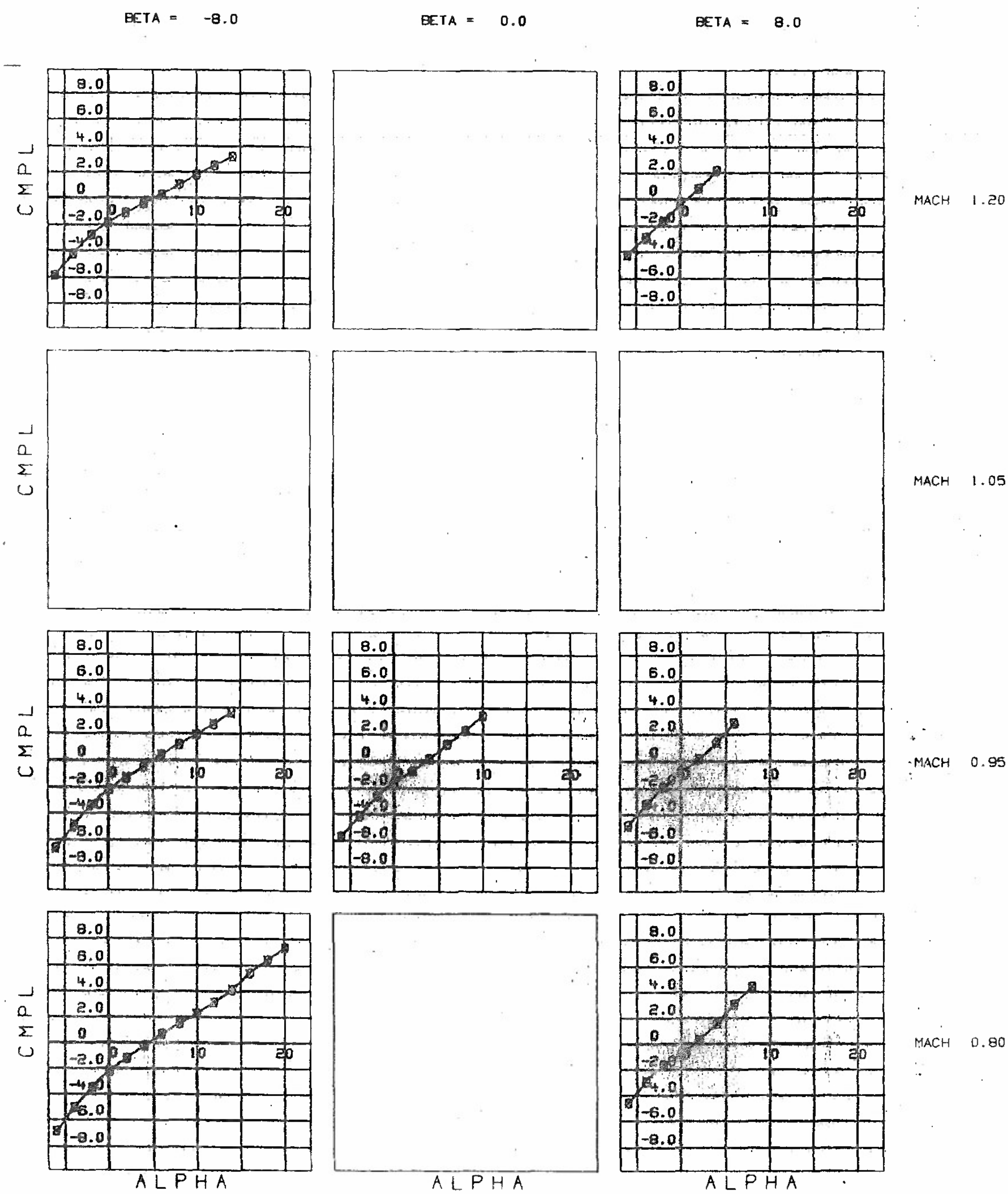


Figure 49. Hysteresis Data - CMPL vs ALPHA

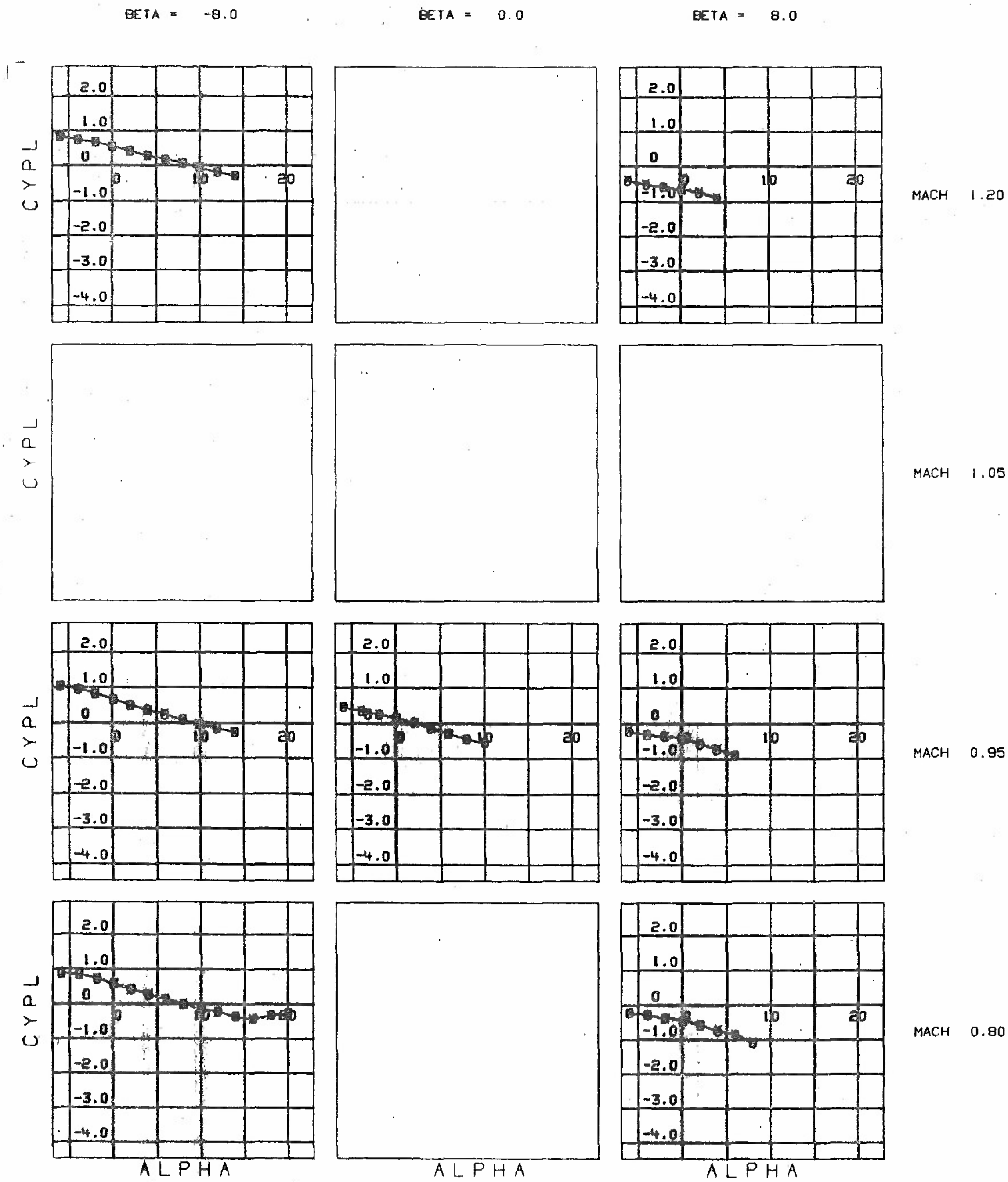


Figure 50, Hysteresis Data - CYPL vs ALPHA

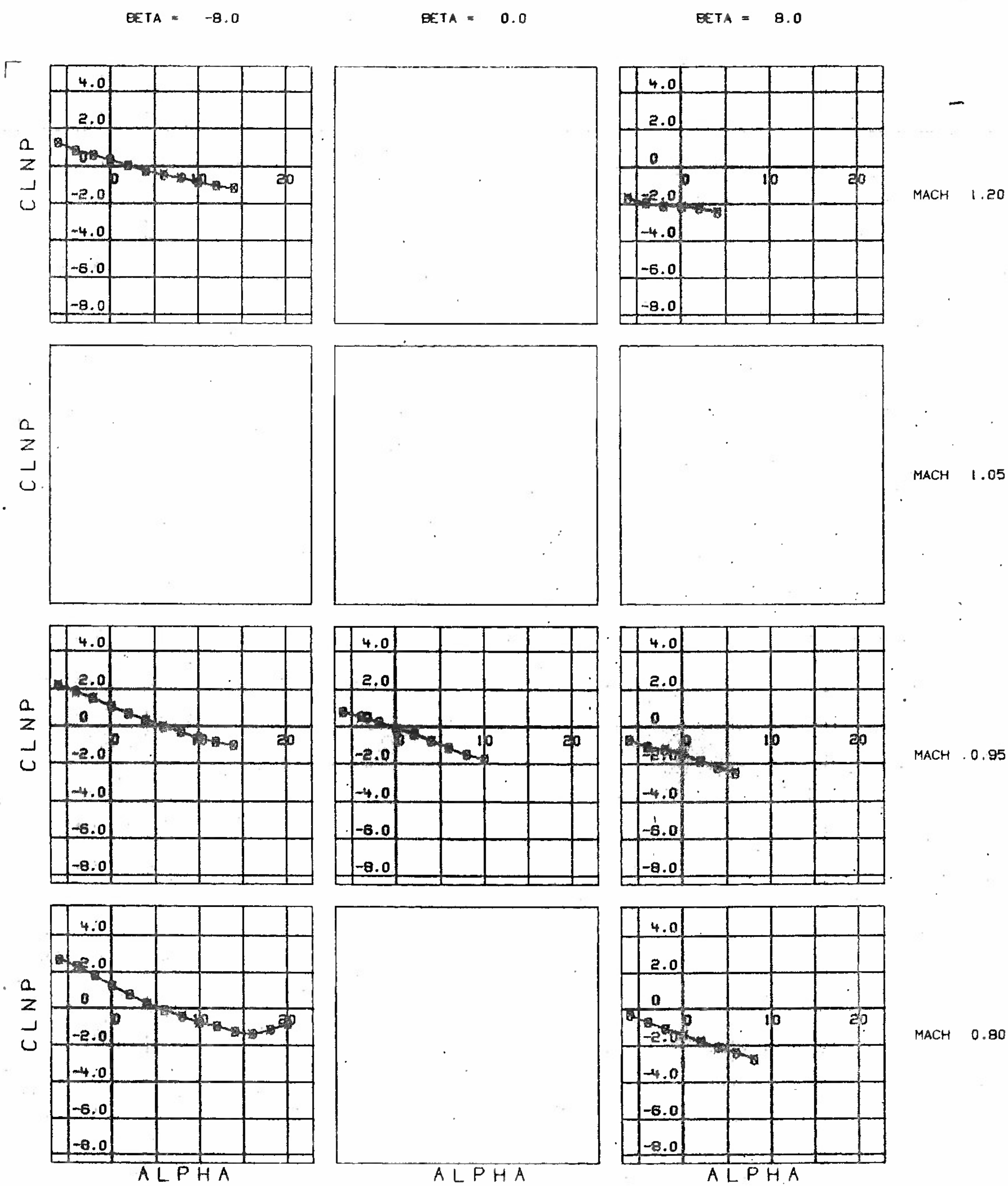


Figure 51, Hysteresis Data - CLNP vs ALPHA

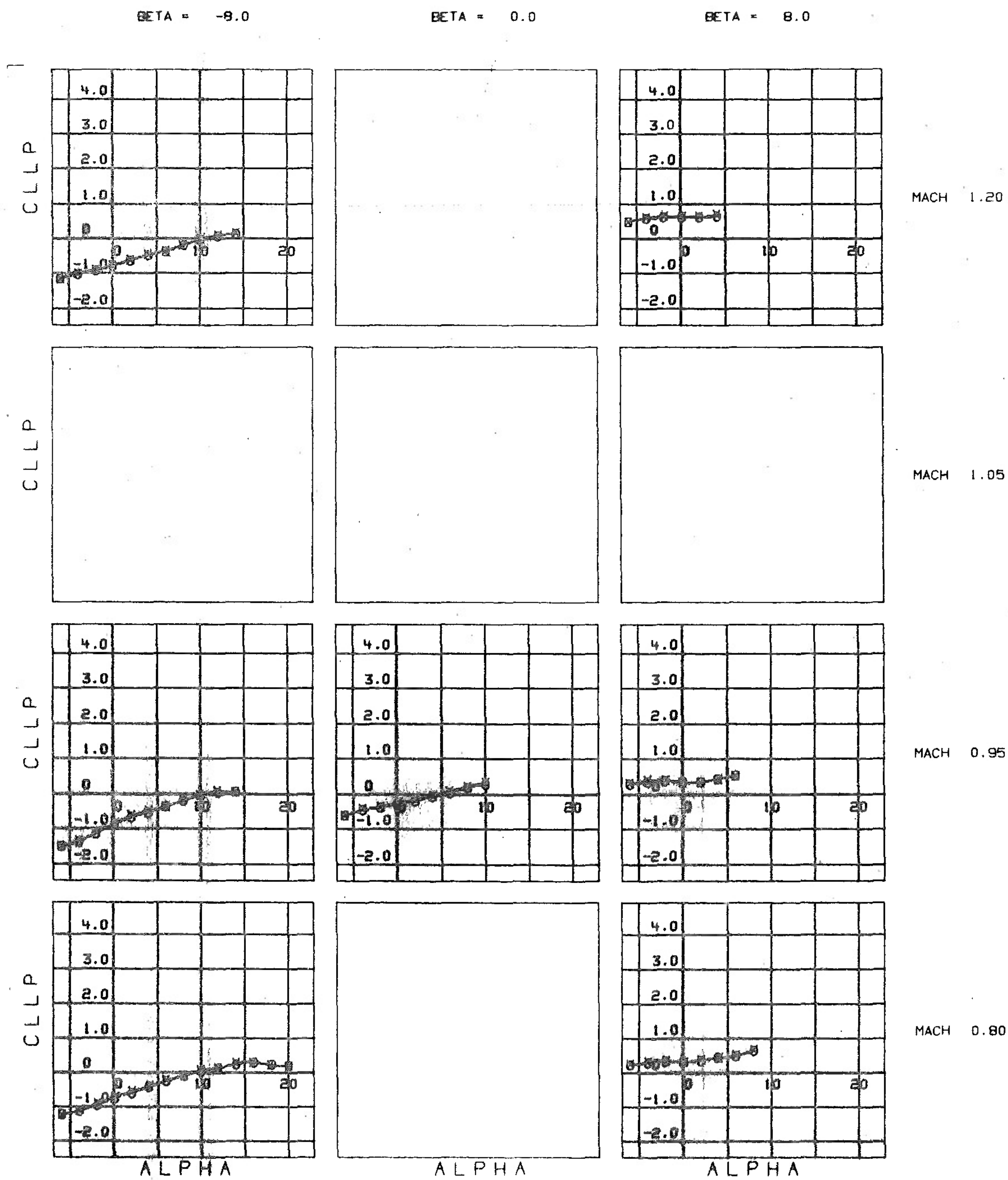


Figure 52. Hysteresis Data - CLLP vs ALPHA

REFERENCES

1. "Test Facilities Handbook", Arnold Engineering Development Center, Arnold Air Force Station, Tenn. July 1971.

2. Whoric, J. M., "Documentation of the F-15 Model Static Stability and Carriage Loads for Various External Store Configurations", AEDC-DR-77-94. ARO, Inc., Arnold AFS TN.

3. White, Warren E., "Store and Store-Pylon Loads Test on a 7.5 Percent Scale Model of the F-15 Aircraft at Mach Numbers from 0.8 to 2.2", AEDC-TR-70-226, ARO, Inc., Arnold AFS TN.